Electrochemical Industry

VOL. I. PHILADELPHIA, MAY 1, 1903. NO. 9.

Electrochemical Industry

Published on the first of each month by the

ELECTROCHEMICAL PUBLISHING COMPANY,

[*Incorporated.*]

CITY TRUST BUILDING, PHILADELPHIA, PA.

J. W. RICHARDS, PH.D. ....*President.*

E. F. ROEBER, PH.D. ....*Editor.*

Long Distance Telephone 3-51-24.

Subscription Price: $2 per year, postpaid to any part of the world. Single copies, 25 cents.

SUBSCRIPTIONS MAY COMMENCE FROM VOL. I, NO. I (SEPT. 1902)

ADVERTISING RATES GIVEN ON APPLICATION.

Entered October 24, 1902, at Philadelphia, Pa., as Second-Class Matter, under Act of Congress of March 3, 1879.

CONTENTS.

NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The third general meeting of the American Electrochemical Society, held at New York City, from April 16th to 18th, turned out to be, as a whole, the most successful meeting which the Society has had, especially in its social features, which had been admirably arranged by the local committee. The attendance was large, the number of members and guests who registered being 260. The enthusiasm of the members and the cordial relations between the various classes of workers in the electrochemical field were the same as in former meetings. This is most important, as it proves that the vigor and enthusiasm displayed so conspicuously at the Philadelphia and Niagara Falls meetings were not simply due to the "nascent state" of the Society, but that the Society really fills a need.

It is a matter of special satisfaction that at its New York meeting the young society entered into cordial relations with some of its chemical and electrical sister societies. The Chemists' Club, which tends to become the New York center of the whole chemical activity of this country, extended the hospitality of its club house to the Society, and the American Institute of Electrical Engineers invited the American Electrochemical Society to a joint meeting, at which an excellent experimental lecture by Mr. Hammer, on some subjects relating to the borderland of science, was greatly enjoyed. We hope that this will turn out to be only the first of a long series of joint meetings, and that in this way the American Electrochemical Society will become an important factor in bringing chemists and electrical engineers together. The advantages which may be obtained from such intercourse for both chemistry and electrical engineering cannot be overestimated.

On the following pages we give a complete account of the proceedings, and it is sufficient to state here that the technical programme was of the same high order as at the former meetings. There was again a long list of good papers on timely and important electrochemical subjects. In fact, the technical programme was rather too much crowded. The inherent disadvantage of a crowded programme is that the discussion falls short. Several important papers read in New York were not discussed at all. This is greatly to be regretted, because a good general discussion is equally as important as a good paper. Points which an engineer would not like to put into a paper for commercial or other reasons are often brought out in a discussion. A good discussion is the ideal supplement to a good paper.

The main condition by which a good general discussion is made possible is that the papers are printed in advance and sent to the members before the meeting. The first step in this direction was made at the New York meeting with some of

the papers, although the "advance copies" arrived after several of the papers had been read, so that the real object of printing a paper in advance was not accomplished. Anyhow, the first step has been done in the right direction, and we trust that at future meetings advance copies of a greater number of papers will be in the hands of the members before they leave their homes for the place of meeting.

Among the papers on more practical subjects there were three on various details of the electrodeposition of metals, one on copper refining, one on the electrolytic production of metallic compounds, especially white lead, two on storage batteries and one on the corrosion of metals by electrolysis. In another paper the search for an insulating material of all-around perfectness was pointed out to be a promising field for chemical investigations. The balance of the papers were of a more theoretical nature. We are glad to note that discussions of questions of physical chemistry meet with the interest of the members of the Society. Physical chemistry is not a branch of chemistry, like analytical chemistry; physical chemistry is general chemistry.

About half the number of the authors were practical or consulting engineers; the other half represented American universities. The University of Wisconsin alone was represented by six authors, with four papers in all. The other American universities represented by papers were Cornell, Lehigh, University of Michigan, Johns Hopkins and McGill University. While it is perfectly true that, as Dr. Richards remarked in his presidential address, we are out of comparison with Germany with respect to the number of chairs of electrochemistry and well-equipped electrochemical laboratories, yet it must be said, on the other hand, that the splendid and vigorous activity of a few American universities in the field of electrochemistry is all the more conspicuous.

We said above that the programme of the New York meeting was somewhat too crowded. The most certain remedy for the future would be to carry into effect a suggestion which was put forward by us in these columns in our last issue, and which was also advocated in the official report of the secretary, Mr. C. J. Reed. Mr. Reed pointed out that while it may still appear to be too early now to do anything towards the establishment of local branch organizations, yet, at the present rate of increase of members, such local branches may very soon become desirable, if not a necessity. If we may use the terminology of electric central-station engineers, we may say that the load curve, representing at present the work of the Society, is nearly at zero for the greatest part of the year, and shows two very sharp peaks at the two general meetings. Now, in central-station practice, and in the work of a technical society, a more uniform load is very desirable. Such a more uniform load would be obtained for the American Electrochemical Society by the formation of local branches, with short, but more frequent, local meetings. The two general meetings would thereby lose nothing of their splendor, as they would remain the only meetings at which the electrochemists of the whole country would come together.

APPLICATION OF THE ELECTROLYTIC DISSOCIATION THEORY TO MEDICINE AND BIOLOGY.

In the synopsis of our issue of last month reference was made to the growing abuse of the electrolytic dissociation theory, and of the teachings of physical chemistry by physicians in charge of mineral springs in Germany. It was pointed out that such abuse may bring the whole physical chemistry into disrepute. At least there is danger that this abuse may become so disgusting to true physicians and biologists that they will forget what the electrolytic dissociation theory has really accomplished for medicine and biology, and what it may be expected to accomplish in future.

It is therefore with great pleasure that we publish in this issue a paper by Dr. Bancroft on this very subject. One of the notable features of this paper is the conservative and truly scientific spirit in which the dissociation theory is dealt with. Its achievements are clearly pointed out, and with equal frankness it is stated where its assumptions fail. Further, the paper is an interesting proof of the almost unlimited field of the applications of electrochemical theories. One special point we may still mention: it is the pretty analogy with the large and small boy running together used by Dr. Bancroft for explaining how hydrochloric acid may get into the stomach. This analogy should be very useful for explaining to students the essential idea of Nernst's theories of diffusion and of concentration cells. It seems to us more important that a student should clearly grasp the fundamental idea of a theory by such a simple analogy than that he should go through a long series of mathematical deductions and formulas, as is generally done in this case, even in elementary text-books.

REVOLVING ELECTRODES IN FACTORY AND LABORATORY.

A recent Chemical Society paper, by Dr. Edgar F. Smith, on an important departure from the usual procedure in electrochemical analysis by the direct precipitation of metals, shows a curious instance of a case in which the laboratory has lagged behind the factory. Nearly thirty years ago Wilde began the use of rotating electrodes in metal deposition, his purpose being to obtain a smooth deposit with higher current densities than could otherwise be used, and more recently Cowper-Coles has greatly developed the matter, determining the exact relation which exists between speed of rotation and current density. Other workers have not been idle, and the patents and literature contain numerous instances of work done under these conditions. A very interesting contribution to the literature on this subject is Mr. J. G. Zimmerman's Electrochemical Society paper, an abstract of which is given on one of the following pages.

Now it seems that it has been discovered that what operates well on a large scale in the factory will serve equally well on a small scale in the analytical laboratory, and that, by imparting a rapid movement of rotation to one or the other electrode, various metals may be separated in condition suitable for weighing and with great economy of time. We have long been taught, and truly, that the laboratory is the fountain-head of progress; that what are to-day the manipulations of the

scientific chemist may become to-morrow the methods of the manufacturer. But has the chemist ever adequately considered to what extent he might benefit by adopting for his own use the successful and carefully-elaborated methods of the factory?

MR. CARNEGIE'S GIFT FOR A UNION ENGINEERING BUILDING.

For many years suggestions have been made to unite the official seats of the various national engineering societies in one and the same building in New York City. This building should at the same time contain all the libraries of the different societies, a large assembly hall for conventions, smaller halls for council and committee meetings and club rooms, with accommodations for the comfort of members visiting New York. These suggestions, although repeatedly made, were never carried into effect, the main reasons for the failure being a lack of enthusiastic harmony and the difference in the financial resources of the different societies. It was to be expected that in the present era of "trusts" the above scheme would again be taken up with greater engineering skill and greater energy. While we are going to press we are informed that the project is now approaching realization.

The Engineers' Club, which is a social organization of engineers in New York City, recently decided to build a new club house on Fortieth street, between Fifth and Sixth avenues. It is now proposed that the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers shall unite with the Engineers' Club, and that a large Union Engineering Building shall be erected, running from Thirty-ninth to Fortieth street, between Fifth and Sixth avenues. The important factor which makes the realization of this plan possible and almost sure is the generous offer of $1,000,000 by Mr. Andrew Carnegie for the erection of this building. The lots for the building are to be bought by the various societies.

A meeting of representatives of different societies interested in this scheme was held on May 7th, and, while there was some discussion as to the best means of carrying out the project, there was a general harmony in the expressions of hearty accord with the general scheme. It may be that one of the national societies mentioned above, which has already a building of its own, may hesitate to join, but it is hoped that this society will leave aside its own individual preferences and will join with the others.

It is almost superfluous to point out what the realization of this scheme would mean. We may only mention the project to place all the libraries of the different societies, although in separate rooms, yet on one floor. What a magnificent general engineering library would thus be obtained. Moreover, the personal intercourse between engineers of various branches would bring about results the importance of which cannot be estimated at present. From the experience of the American Electrochemical Society, we know how many fruitful suggestions, thoughts and ideas an electrical engineer may get from his exchange of ideas with a chemist, or just as well a chemist from an electrical engineer. Should we not hope that the bringing together of all the great national societies in one Union Engineering Building should be equally, or even more, effective? We may briefly mention that the original plan is to have other engineering societies join with the large ones above mentioned in occupying the building. It may be doubted whether Mr. Carnegie ever donated a gift for a purpose more ideal and at the same time more promising than the building of a Union Engineering Building.

ELECTRICAL ENDOSMOSE.

Since the classical investigations of Hittorf and Kohlrausch it has become customary to consider the electric conduction in an electrolyte as a mechanical problem, all the changes which go on in the solution being explained by migrations of ions. As far as this theory goes, it has been confirmed by various experiments. Now, in many investigations it is desirable or necessary to keep the anodic and cathodic departments separate. This is done by a diaphragm, and it has generally been assumed that such a diaphragm is inert and has no influence on the migration of the ions. We know that this assumption is wrong, because the phenomenon called electric "endosmose" is a well-established experimental fact. This is of theoretical as well as experimental importance.

In a paper of Hittorf, published last year, the author corrected some older values of his migration numbers, the error in his former determinations being due to special properties of the diaphragms used in his old tests. The discrepancies between experimental facts and the dissociation theory, pointed out by Mr. C. J. Reed in an American Electrochemical Society paper, read at Niagara Falls, may also be due to the phenomenon of endosmose. At the recent New York meeting Dr. Bancroft pointed out that in some cases the concentration changes due to endosmose is much larger than is generally assumed. He also pointed out that to a certain degree it is possible, by choice of the nature of the diaphragm, to regulate the endosmose at will. From this point of view the matter becomes of the greatest practical importance. The subject deserves the most careful experimental study, in view of the fact that we know very little about this phenomenon and that from a careful investigation we may expect very important results for theory as well as for practical applications.

The present situation is that, for certain practical electrolytic processes, diaphragms are required, and that the opinion has been prevalent that the only purpose of these diaphragms is to keep the compartments of the cell separate and prevent the mixing together of their contents. At the same time the diaphragms should not hinder the migration of the ions, which makes the required electrochemical action possible. The opinion has been prevalent that it is only necessary to use a diaphragm of sufficient mechanical strength and of low electric resistance, which is a somewhat inexact expression, for the requirement that the joint resistance of the electrolytic paths through the pores of the diaphragm should be low. It had been silently assumed that the diaphragm itself does in no way influence the electrolytic action which goes on. But the phenomenon of electric endosmose proves that this view is wrong.

FIFTH INTERNATIONAL CONGRESS FOR APPLIED CHEMISTRY, AND ANNUAL MEETING OF THE GERMAN BUNSEN SOCIETY.

The annual meeting of the German Bunsen Society will be held in Berlin, from June 2d to 8th, in connection with the Fifth International Congress for Applied Chemistry.

The following papers have been announced:

L. Ancel, Paris: On the Variations of Electric Resistance Under the Influence of Light, of Other Bodies than Selenium.

W. D. Bancroft, Ithaca: Experiments with Metallic Diaphragms—Constant Voltage and Constant-Current Separations.

G. Bodlaender, Braunschweig: On the Technical Application of Catalysis.

G. Bredig, Heidelberg: The Application of Electric Endosmosis and the Phenomena of the Colloidal Condition.

Desiré Corda, Paris: On Electromagnetic Separation of Minerals. Industrial Applications of Electrolytic Calcium.

A. Coehn, Goettingen: On Specific Metal Actions in Electrolytic Reduction and Oxidation.

K. Elbs, Giessen, and M. Buchner, Mannheim: On the Importance of Electrochemistry for Synthetic Organic Chemistry.

G. Erlwein, Berlin: On the Application of Electricity for the Utilization of Atmospheric Nitrogen.

F. Foerster, Dresden, and Brandeis, Aussig: On the Application of Electrolysis to the Preparation of Inorganic Compounds.

O. Froelich, Berlin: On a New Electric Resistance Furnace.

H. Gall, Paris: The Taking of Samples and Analysis in the Carbide and Acetylene Industries.

G. Gin, Paris: The Manufacture of Aluminium.

H. Goldschmidt, Christiania: On Reduction Methods.

H. Goldschmidt, Essen: The Manufacture of Steel in the Electric Furnace.

H. Grossmann, Muenster: On the Capability of the Rhodanion to Form Complex Compounds, as Compared with Halogen Anions and the Cyanion.

A. Guntz, Nancy: On the Preparation of Barium.

J. B. C. Kershaw, London: On Aluminium as an Electrical Conductor.

F. W. Kuester, Clausthal: Dissociation Pressure of Salt Solutions.

P. Lebeau, Paris: On Silicium Compounds.

M. Le Blanc, Karlsruhe: On Electrolysis with Alternating Currents.

G. Magnanini, Modena: On the Physical Chemistry of Wine.

W. Marckwald, Berlin: On Radio-active Substances.

P. Sabatier, Toulouse: On Catalysis.

H. Moissan, Paris: On Metallic Carbides.

W. Nernst, Goettingen: On Electrochemical Units. On the Determination of Vapor Densities at Very High Temperatures.

H. Nissenson, Stolberg, and H. Danneel, Breslau: The Quantitative Precipitation and Separation of Metals by Electrolysis.

F. Peters, Berlin: Storage Batteries without Lead.

P. Sabatier, Toulouse: On Catalysis.

Count Schwerin, Hoechst: On Practical Applications of Electric Endosmosis.

R. Schenk, Marburg: On the Dissociation of Carbonic Acid.

A. Sinding-Larsen, Fredriksvaern: Pseudo-molecular Compounds and Kryohydrates. Some Capillarity Phenomena and their Relation to Osmotic Pressure and Dissociation.

Edw. R. Taylor, Penn Yan: The Manufacture of Bisulphide of Carbon in the Electric Furnace.

J. H. Vogel, Berlin: Impurities in Commercial Acetylene.

E. Wedekind, Tuebingen: On the Chemical and Electrochemical Preparation of Zirconium and on Colloidal Zirconium.

C. Zengelis, Athens: On Chemical Reactions at Extremely High Temperatures.

THE GIFT OF MR. ANDREW CARNEGIE FOR A UNION ENGINEERING BUILDING.

Mr. Andrew Carnegie has offered $1,000,000 to build a New York City home for the Engineers' Club of New York and for the following four national societies: The American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers.

The Engineers' Club has already purchased two lots for its building on Fortieth street, and, as Mr. Carnegie requires that the societies furnish the ground for the building, options have been obtained on five lots on the north side of Thirty-ninth street. Mr. Carnegie has advanced sufficient money to secure the options on the required property that must be purchased. The cost of the lots on Thirty-ninth street, to be bought by the four national societies, will be between $500,000 and $600,000.

None of the societies has so far been officially authorized to enter into the scheme. It is, however, certain that the electrical engineers and the mechanical engineers will accept the offer. The latter society had almost completed arrangements for a $350,000 building of its own, as its present quarters, on Thirty-first street, have been outgrown. The committee of the Institute of Electrical Engineers appointed to collect funds for a home of the society has declared itself enthusiastically in favor of the project. At the time we are going to press no exact information could be had concerning the attitude of the mining engineers and the civil engineers towards the scheme. The latter society has already a fine home.

An informal meeting of officers and prominent members of the various societies which are interested in the scheme was held on May 7th, and a joint committee, made up of three representatives of each of the societies, was arranged for, and it is probable that a meeting of this committee will shortly be held. It is readily understood that the official machinery of the various organizations does not permit of offhand acceptance of Mr. Carnegie's generous proposition.

THE JOHN FRITZ MEDAL.

As is well known, the establishment of the John Fritz medal was signalized last year to celebrate the eightieth birthday of Mr. John Fritz, the fund collected for this purpose having been contributed by about 480 subscribers.

At Albany, N. Y., on April 18th, articles of incorporation of the John Fritz Medal Fund Corporation were filed with the Secretary of State. It is formed to collect and hold funds for a permanent investment, the proceeds of which will be used in the purchase of the gold medal to be known as the John Fritz medal, to be awarded annually to the person who shall be selected as having made the most notable scientific or industrial achievement during the period since the last award.

The medal is named to perpetuate the memory of John Fritz, Bethlehem, Pa., and the Board of Award is made up of members of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The directors of the corporation are J. J. R. Croes, Alfred Noble, C. W. Hunt, E. E. Olcott, E. G. Spilsbury, James Douglas and C. Kirchhoff, of New York City; Robert Moore, of St. Louis; Gaetano Lanza, of Boston; John E. Sweet, of Syracuse; Robert W. Hunt, of Chicago; S. T. Wellman, of Cleveland; Arthur E. Kennelly, Cambridge, Mass.; Carl Hering, of Philadelphia; Charles P. Steinmetz, of Schenectady, and Charles F. Scott, of Pittsburg.

The Gordon Battery Co. of New York have recently issued a booklet on the Gordon battery, giving some information regarding primary batteries in general, with illustrations and prices of the various sizes and types of the Gordon cell, besides the line of Gordon supplies.

SOME APPLICATIONS OF THE ELECTROLYTIC DISSOCIATION THEORY TO MEDICINE AND BIOLOGY.*

By Wilder D. Bancroft.

If we dissolve a lump of sugar in water, we get a solution which does not conduct electricity, and which freezes at a lower temperature than pure water. The lowering of the freezing point depends on the concentration and the molecular weight of the sugar. If we dissolve a pinch of salt in water, we get a solution which conducts electricity, and which freezes at a lower temperature than pure water. The lowering of the freezing point is greater than we should expect from the concentration and molecular weight of the salt; in dilute solutions nearly twice as great. We account for the electrolytic conduction and the abnormal freezing point by assuming that salt dissociates to a certain extent in aqueous solution into electrically-charged sodium as ion, and electrically-charged chlorine as ion. An aqueous salt solution consists, therefore, of water, undissociated sodium chloride, sodium as ion and chlorine as ion. The electrolytic conductivity is due to the presence of the electrically-charged ions. With increasing dilution, the undissociated sodium chloride breaks up further into sodium as ion and chlorine as ion. Since solutions of other salts, of bases and of acids give abnormal freezing points and conduct electricity to a greater or lesser extent, we assume that these solutions are also dissociated into positive and negative ions, corresponding to the basic and acid radicals.

It may be asked whether this is all true. That is a question which no one can answer just now, and which is of no importance to us to-night. The electrolytic dissociation theory has proved useful as a working hypothesis, and has enabled us to predict a number of interesting facts. These facts will remain whether we continue to interpret them in the light of the dissociation theory or not.

Part of our assumption was that the ratio of undissociated salt to dissociated salt varied with the concentration, approaching zero for infinite dilution. The equilibrium will also be changed by adding either of the dissociation products. If we add a chloride to a solution of sodium chloride, we increase the concentration of chlorine as ion, and consequently the dissociation is forced back and more undissociated sodium chloride is formed. If the solution is already saturated with respect to sodium chloride, the excess of undissociated sodium chloride will separate as solid salt, and we have a case of decreased solubility. This can be shown very well by adding concentrated hydrochloric acid to a saturated barium chloride solution. The precipitate of barium chloride will dissolve on addition of water, and again be precipitated on addition of more hydrochloric acid.

Since the properties of a solution are the resultant of the properties of the components, we shall expect to find substances in the state of ions endowed with specific properties. This is the case, color being a striking instance of it. Dilute solutions of copper sulphate, nitrate, chloride and bromide are all blue, and we therefore postulate that copper as ion is blue. At higher concentrations these different salt solutions have different colors, presumably because of the color of the undissociated salt. In the same way most cobalt salts in aqueous solution are pink, owing to the presence of cobalt as ion; and most nickel salts green, owing to the presence of nickel as ion. It must be admitted that there are points not covered by the theory. The change of color with the dilution cannot be predicted quantitatively, and in benzene solutions we get the characteristic colors of the metals as ions, even though the solutions do not conduct electricity at all.

Coming back to dilute aqueous solutions, where the difficulties are least noticeable, we should expect that mixing two colored solutions would give us the color due to the single solutions if no special reaction takes place on mixing, and some other color if a reaction does take place. It is possible to make a cobalt salt solution and a nickel salt solution such that the pink and green are very nearly complementary. If we place these two solutions in plane-walled glass vessels and look through the two, we get the additive effect of the colors, any chemical action of one solution on the other being prevented by the separating glass walls. We can then mix these solutions, and we find experimentally that we get the same nearly colorless solution that we had previously obtained by superposition. If we try a similar experiment with a potassium cyanide solution and a copper sulphate solution, we get a different result. The color of the superposed solutions is blue. The mixed solution is colorless. From this we conclude that a reaction has taken place. On investigation we find that we have in the mixed solution the potassium salt of cuprocyanic acid, in which copper is part of the acid radical. Since copper is not present as ion, there is no reason that the solution should show the blue color of copper as ion.

Since certain solutions have a toxic action on certain plants or animals, it is not unreasonable to expect that in some cases the toxic action may be due to a certain ion. If we find that a certain metal as ion is toxic, while the undissociated salt is not, we should expect to get the greatest toxic action for a given concentration of metal when that metal is present in the form of a highly-dissociated salt. This has been found to be the case. A mercuric chloride or mercuric bromide solution is much more rapidly fatal to some forms of bacilli than a solution of mercuric cyanide containing the same amount of mercury per liter. The difference in the two cases is due to the fact that the concentration of mercury as ion is much less in the cyanide solution than in the chloride or bromide solution. Dreser has found that the action on fishes of mercury in the form of potassium mercuric thiosulphate is much less rapid than is the action of an equal amount of mercury in the form of chloride. With warm-blooded animals, such as the rabbit, no such difference was observed, presumably because the complex thiosulphate was decomposed rapidly. Kahlenberg and True found that seedlings of *Lupius albus* were killed by a concentration of 1.5 milligrams of copper per liter when the copper was present as sulphate, while they flourished in an alkaline sugar solution, even when the concentration of copper reached 160 milligrams per liter. It is not to be supposed from these instances that ions alone are toxic, and that the undissociated salt is always harmless. Kahlenberg and True found that in the case of mercuric cyanide both ions, and also the undissociated salt, are toxic to *Lupinus albus*. Clark found that undissociated chloracetic acid is more toxic to certain fungi than the dissociation products. Coupin has shown that potassium as ion is beneficial to Bordeaux wheat, and the use of potassium and sodium salts as fertilizers probably depends to some extent on the beneficial properties of certain ions.

On the other hand, it must be kept in mind that there are other factors to be taken into account besides that of electrolytic dissociation. The disinfecting power of carbolic acid solutions is increased by addition of sodium chloride, and decreased by addition of sodium acetate. The deciding factor here is what we call the chemical potential of the carbolic acid. Sodium chloride decreases the solubility of carbolic acid, increasing its chemical potential, and consequently its disinfecting power. Sodium acetate increases the solubility of carbolic acid, decreasing its chemical potential and its disinfecting power. Put in a general form, the properties of a substance are a function of the degree of saturation as well as of concentration. I lay especial stress on this because this is a point which has been pretty generally overlooked hitherto, and which is actually of great importance in many cases.

The cases considered so far have been cases of equilibrium, but we can find interesting instances of the usefulness of the dissociation theory in the field of reaction velocity. If we add an acid to a solution of cane sugar, we find that the sugar is changed gradually into a mixture of dextrose and levulose. This inversion, as it is called, takes place at different rates,

* A Lecture before the American Philosophical Society, March 20, 1903.

depending on the nature and concentration of the acid present, when the temperature and the initial concentration of the sugar are the same in all the experiments. On further investigation it was found that the rate of inversion varied very nearly, not absolutely, proportionally to the concentration of hydrogen as ion, as determined by other methods. It should be noted that, in terms of the electrolytic dissociation theory, any substance which yields hydrogen as ion in an aqueous solution is an acid by definition. This accelerating action of acids, or rather of hydrogen as ion, is not confined to the inversion of sugar. A very large number of reactions are accelerated in a similar manner. Since there is free hydrochloric acid in the human stomach, it occurred to Hoffmann that the rate of digestion might depend on the concentration of hydrogen as ion. To test this hypothesis he determined the rate at which a pepsin solution plus acid acted on albumen. With sulphuric acid there were irregularities, due to a special cause; but with the other acids the rate of digestion was approximately proportional to the concentration of hydrogen as ion. From this point of view, a substitution of acetic acid for hydrochloric acid in the stomach would be a very serious matter. Since the concentration of hydrogen as ion is 300 to 400 times as great in hydrochloric acid solutions as in equivalent acetic acid solutions, a meal that would be digested in three hours with the aid of hydrochloric acid would require three weeks or more with an equivalent quantity of acetic acid. In other words, after a real, old-fashioned Thanksgiving dinner we should begin to feel hungry again about Christmas time. Whether a glass of hydrochloric acid after dinner would be a good thing for a dyspeptic is a matter that lies within the province of the physician, and not of the physical chemist.

How the hydrochloric acid gets into the stomach is a question that may well interest the physical chemist. We eat salt, and it is changed into hydrochloric acid somewhere in and by the system. I asked a physiological chemist about this. He said that the salt gets into the blood, and that certain glands secrete hydrochloric acid back into the stomach, the alkali being neutralized by the carbonic acid in the blood. This explanation calls for a specific secreting power on the part of certain glands. It is interesting to note, however, that the physical chemist can get hydrochloric acid from salt without postulating a specific secreting power on the part of any of his apparatus. If we place a salt solution in a porous cup and stand the porous cup in water, there will be a diffusion of salt through the walls of the cup. Now, chlorine as ion tends to diffuse faster than sodium as ion, but is held back by the latter because of the electrostatic effects that would be caused if there were an excess of negatively-charged ions outside the cup and an excess of positively-charged ions inside the cup. The rate of diffusion of sodium chloride is therefore intermediate between the rates at which sodium as ion and chlorine as ion tends to diffuse. If a big boy keeps hold of his small brother's hand, the two will run faster than the little fellow alone, but not as fast as the big brother alone. Suppose we now add a weak acid to the salt solution, carbonic acid, lactic acid or acetic acid. It is necessary that equal amounts of positively and negatively-charged ions shall pass through the diaphragm at any moment, but that is the only restriction. Consequently we shall have the faster positive ion and the faster negative ion diffusing as one substance, leaving the slower pair behind. Hydrogen as ion tends to diffuse faster than any other known ion, and we therefore have hydrochloric acid diffusing from a mixture of sodium chloride and lactic or acetic acid, for instance. The porous cup is merely a dividing surface, and no specific properties are attributed to it. In view of the fact that secretion of hydrochloric acid might take place if the glands in question had no specific secreting power, we are justified in asking the physiological chemist to prove that these glands have a specific secreting power.

Another very interesting set of experiments has been carried on by Bredig, first in Ostwald's laboratory, at Leipzig, and later in his own laboratory at Heidelberg. The change of hydrogen dioxide into water and oxygen is accelerated by the presence of organic ferments, among others by blood corpuscles. The reaction is also accelerated by colloidal metals, platinum, silver, etc. For this reason these colloidal metals have been called inorganic ferments. This name would not be especially appropriate were it not for the fact that many substances have the same paralyzing effect, both on the blood corpuscles and on colloidal platinum. Thus prussic acid, mercuric chloride, hydrogen sulphide, hydroxylamine, cyanide of mercury, etc., all reduce greatly the accelerating action of platinum and of the red blood corpuscles on hydrogen peroxide. The parallelism is not absolute, however. It exists in about two-thirds of the cases thus far studied.

A most remarkable fact about these inorganic ferments is the dilution at which they work. The effect of colloidal platinum is noticeable when we have only one milligram of platinum suspended in 300 liters of water. In view of this, it no longer seems unreasonable that traces of arsenic in the thyroid gland should be essential to health, and the necessity for iron in the system is seen in a new light when we learn that iron salts exert a marked accelerating influence on many reactions involving oxidation.

Of great physiological importance is an entirely different class of phenomena, that involving a so-called semipermeable membrane. A semipermeable membrane is one which lets one of the components of a solution pass through, usually the water, and holds back the other. It is a membrane, in other words, which permits selective diffusion, or specific secretion if one so wishes. In view of the fact that many animal membranes are more or less semipermeable, it is quite possible that the secretion of the hydrochloric acid into the stomach may be due to a specific property of the glands.

When a solution is separated from the pure solvent by a membrane permeable to the solvent and impermeable to the solute, the solvent tends to pass through the membrane to dilute the solution. If this diffusion of the solvent is to be prevented, it is found that pressures of several atmospheres are necessary in dilute solutions, and that these pressures increase with increasing concentration of the solution. The membranes surrounding many plant cells are semipermeable, and the osmotic pressure of the contents, or the pull on the solvent, is about four and one-half atmospheres. This osmotic pressure is one of the important factors in determining the rise of sap in trees, capillarity being, of course, another factor. This pressure alone would cause sap to rise 140 to 150 feet, which is about as high as many of our trees grow. The corollary of this is that the cells of the California giant Sequoias must contain a more concentrated solution than those of our local plants. Unfortunately, no enthusiastic physical chemist has yet tested this hypothesis.

While the physical chemist is perfectly satisfied with the fact that the osmotic pressure in the plant cells is sufficient to account for the rise of the sap, the unfortunate botanist has to explain how the cells are formed. When you stop to think of it, the second row of cells presents difficulties. How did the salts for the second row get through the cells in the first row when these are impermeable to the salts by definition? The only answer possible is that the cells are not absolutely impermeable to the salts. The following experiment will show this. If we place a cut plant in a concentrated salt solution, the plant droops, because water flows out of the plant cells into the more concentrated solution. In time, however, the plant stiffens again, salt having diffused into the cell. This can be carried so far that salt crystallizes on the leaves of the plant. An animal which was in equilibrium with salt water would have to swell to ten times its bulk in fresh water if its cell walls were really impermeable. This diffusion of the protoplasmic salts has recently been shown experimentally in the case of *Linnæa stagnalis*.

In at least one instance a recognition of the osmotic relations

has been of great value in surgery. At one time surgeons used to wash out the abdominal cavity with water. This water was, of course, absorbed to some extent, causing the cell walls to become turgid, and then to burst. Now they wash out the cavity with a salt solution, of such strength that there is little or no tendency for water to pass in either direction. There is then no bleeding due to rupture of the cell walls. The "physiological saline salution," as it is called, should contain about 0.9 per cent. sodium chloride, in order to be in equilibrium with the cell walls. It is, as a matter of fact, a 0.6 per cent. solution. I have been told that this weaker solution is taken so as to be on the safe side in case of carelessness in making it up, the natural tendency being always to give full measure.

As the latest application of the electrolyte dissociation theory we have the work of Loeb and of Matthews on the stimulating action of certain substances as ions.

ELECTROLYTIC PRODUCTION OF METALLIC COMPOUNDS.

A very important paper, which should be carefully studied by any electrochemist interested in this subject, was presented by PROF. C. F. BURGESS and MR. CARL HAMBUECHEN, of the University of Wisconsin, at the recent New York meeting of the American Electrochemical Society. In the following we give an abstract of the paper:

The purpose of the paper is not to present an ideal or even an improved process for producing metallic compounds, but rather to point out the limitation of the methods at present available and to deal with some of the difficulties which must be encountered in large scale working.

Electrical energy suitably applied to a soluble sulphate, chloride, nitrate or similar salt of one of the alkali metals may produce a dissolving action upon a metal anode, with a consequent production of a salt of that metal similar to that which would be produced by ordinary chemical corrosion by a corresponding acid. It is from this fact that arises the commercial possibility of replacing acids commonly used by cheaper substances. Thus, in the production of metal sulphate or chloride, it is cheaper to obtain the SO_4 or Cl from a sodium salt than from the acid, especially in such localities where, by reason of freight rates or other circumstances, the acid may be of relatively high price.

A metal nitrate may be produced much more economically from sodium nitrate than from the nitric acid, as far as cost of materials is concerned. Figured on the basis of NO_3 content, 1.35 pounds of sodium nitrate is equivalent to 1 pound of nitric acid, and, at present market values, represents a relative cost of 2.7 cents and 8 cents. Similar relative values might be shown in other cases.

Compensating for this saving in the cost of materials is the cost of power necessary in electrolytic operations, but where the process can be carried out on a large scale this cost can be made insignificant. The amount of energy necessary to decompose 1.35 pounds of sodium nitrate in the production of metal compound will be in the neighborhood of one-quarter horsepower hour, which, at a cost of .5 cent, makes the cost per pound about .15 cent. A further advantage for the electrolytic process is the possibility of recovery of valuable cathode products, one of which, in the case above considered, is .6 pound sodium hydroxide, representing a value considerably more than the cost of power.

To realize the advantages for electrolytic methods which such reasoning makes apparent requires suitable design of electrolytic apparatus. The necessary complications of such apparatus may, with justice, be urged as favoring the purely chemical methods, but as partially or even more than offsetting this disadvantage is the fact that from a given metal surface corrosion may usually be caused to take place with much greater rapidity through the aid of electric current than without. This produces economy of floor space and volume of apparatus.

The metal compounds which may be produced may be classified as soluble or insoluble, in accordance with the dissolving power of water for them. The chemical method for producing soluble metal compounds is typified in the action of an acid on a metal, either directly or indirectly; and the insoluble metal compounds may be produced from solutions of the former by precipitation by a carbonate, hydroxide or other precipitating agent. The double decomposition thus taking place results in the formation of a soluble salt as a by-product, which is usually of such a nature as to be difficult to recover in a pure state with an expenditure of energy sutnciently low to warrant it.

As compared with such chemical method, the advantages which can be obtained by the electrical current are the following: The dissolving acid and the precipitating base may be replaced by a cheaper salt, which is made by the electrical current to exert the dissolving action at the anode with the simultaneous formation of an alkali product at the cathode, and the subsequent union of these two products producing a precipitate with a regeneration of the original salt. This salt may be used over again, and does not represent a waste product. There is, therefore, no expensive material required to be consumed. While the electrical energy is a factor which must be taken into account, it is a comparatively unimportant one in figuring the cost of production on a large scale.

To the corrosion of lead and the production of various lead compounds much attention has been given from the electrochemical standpoint, due to the possibility of attaining the advantage of electrolytic over chemical methods in the greatest degree, and on account of the unlimited demand which exists for such products. Associated with the production of white lead is the record of many failures of electrolytic methods, and the older chemical methods still maintain control, in spite of various promises to the contrary.

One of the principal processes which has been employed for the production of a lead hydroxide is one in which the pig lead is used as the anode in a solution of sodium nitrate with a copper or other metal cathode. Faraday's laws tell us that for every ampère hour 3.8 grams of lead should be dissolved; 1.48 grams of sodium hydroxide should be formed at the cathode, and a mixture of these two products would form 4.45 grams of lead hydroxide with the regeneration of salt which was first decomposed. Assuming a current density of 20 ampères per square foot of anode surface, which is within the limits of possibility, the rate at which the lead will be removed or corroded is almost 80 grams per square foot per hour.

Unfortunately for practical operation, the process is far from being as simple as might at first sight be supposed. In the first place, the corrosion at the anode does not take place in an ideal manner; lead nitrate is not produced in such quantities as the application of Faraday's laws would indicate, and the discrepancy is accounted for by the formation of other basic lead compounds which are insoluble or only partially so. The formation of such undesired compounds may result in a waste of the lead, the introduction into the solution of impurities, the partial or complete insulation of the anode and consequent increase in the amount of power and the uneven corrosion of the metal which it is desired to transform.

In the case of sodium nitrate as the electrolyte, the reaction at the cathode is not simply the formation of sodium hydroxide and liberation of hydrogen. Sodium nitrate is reduced to nitrite, then through its lower forms, with the final production of ammonia. This resulting action causes the solution to become alkaline, and explains what at first sight might appear as a surprising fact, namely, that the current efficiency in the production of alkali is greater than 100 per cent.

For the production of lead hydroxide, by the mixing of the anode and cathode products within the cell, the following difficulty would then arise: The alkaline solution acting on the lead hydroxide, which has been precipitated, redissolves some

of it, forming a plumbate, and thus introducing lead as a soluble compound in the solution. The natural effect of a current passing through this compound is to deposit the lead upon the cathode, which is done in such a manner as to produce a loose, non-coherent, spongy mass of lead, which is easily detached, contaminates the product, decreases the efficiency and may even result in short-circuiting the cell.

Further, the production of nitrite at the cathode results, through the diffusion of this substance to the anode, in the formation of a nitrite of lead and basic lead compounds, which increases the difficulty of unsatisfactory corrosion of the anode. The production of ammonia, which, escaping into the air, may be a source of annoyance, also represents a waste material.

It will be self-evident, then, that the solution remaining after the cell has been in operation for some time is decidedly different in its chemical composition from that used at first.

To cause this electrolytic process to operate as is desired requires a design of the electrolyzing apparatus in such a way that the difficulty heretofore mentioned can be avoided or taken into account. It has been the purpose of some investigations which have been carried out in the laboratory of the authors to determine what these conditions are.

The Anode.—In order to bring the current efficiency of corrosion up to 100 per cent., with the formation of no secondary and undesirable products, careful attention must be given to various factors, such as the purity of the anode, its physical structure, current density, density and chemical nature of the electrolyte. The clean corrosion and 100 per cent. efficiency in lead nitrate formation can be attained by having a small amount of free acid in the neighborhood of the anode. The experience of the authors has shown that an acidity of 0.1 normal nitric acid will enable this satisfactory corrosion to be realized on lead plates carrying a current as high as 20 ampères per square foot. This characteristic of corrosion applies not only to lead, but to various other metals.

Cathode.—The reactions at the cathode should be carefully studied to determine qualitatively and quantitatively the reduction products there formed. The material should be such that no cathode corrosion can take place.

The Electrolyte.—This is the most important factor. It influences the character of the corrosion, the character of the primary and secondary electrolytic products, the amount of power necessary and the cost of keeping the solution in working condition. In the case of lead corrosion we are limited to the choice of such electrolytic materials as those whose anion produces, with lead, a soluble lead salt. This indicates the nitrates and acetates, among the cheaper materials, and the chlorides and chlorates, which are less satisfactory on account of higher resistance and lower degree of the solubility of resulting salts.

To overcome the difficulty of contaminating the precipitate with impurities formed at the anode, all that is needed is to draw the solutions from the electrolytic tank and, after having passed them through a filter, cause the precipitation to take place in another vessel. In the same manner, the dissolving action of the cathode solution on the resulting precipitate could be avoided by adding just enough of the cathode solution to cause complete precipitation of the anode products. To realize these conditions requires the complete separation of the two electrode products while in the electrolytic cell. This can be accomplished by means of diaphragms.

A single diaphragm will not serve in this process, as it would cause precipitation to take place within the diaphragm, and a consequent clogging of the same. To avoid such disadvantage, the electrode products may be kept completely separated by the use of two diaphragms. The stock solution feeding the cell is introduced between the two diaphragms, and the electrode solutions are drawn off from their respective compartments. Diffusion of the electrode solutions is prevented by maintaining a positive flow of solution through the diaphragms toward the electrodes at such a rate as to counteract any tendency for diffusion. To maintain a sufficient rate of flow requires a definite difference of pressure, which may be produced by maintaining the level in the various compartments at different heights. This method of separation has been described in United States patent No. 563,553, of A. B. Brown.

In the experience of the authors it was found that the maintaining of a proper difference of level involved a difficulty, because the density of the solution, which is at first the same in all three departments, changes during operation; it increases in the anode compartment and decreases, or remains practically the same, in the cathode compartment. The effect of the increase of density in the anode solution results in an equality of pressure toward the bottom of the cell, although there may be a difference of level at the surface of the solutions. This results in the diffusion of the anode solution into the intermediate, and thus into the cathode compartment. To obviate this an adjustment of the levels of the solutions to correspond with the relative density should be made. Another variable factor is the change of the character of the diaphragm, due to the influences of the solution and the chemical products upon the same. A light, firm canvas has been found to give very satisfactory results, but the alkaline cathode solution and the acidified anode solution act in different degrees upon the two diaphragms in changing the porosity and the rate of diffusion. Temperature and current density also influence this diffusion. The maintaining of a definite, fixed difference of level of solution between various compartments is hardly a satisfactory method of operation.

The authors have found that, by a very simple method, this difference of levels can be automatically adjusted by keeping the level of the solution in the intermediate compartment constant and drawing from the electrode compartments a certain definite *volume* of solution per unit of time. If the rate of diffusion with a given difference of level is not sufficient to supply this volume, the difference of level increases to such an extent that the flow through the diaphragm will be sufficient.

The fact that the lead solution in the anode has a higher density than the solution in any other of the compartments makes it necessary either to maintain very large difference in the level of the anode and the intermediate compartment, or the construction of the electrolytic cell with a limited depth. The authors have found that an anode plate about 8 inches in depth was the largest that could be used with the kinds of diaphragms described.

Anode compartments being limited in depth in the manner shown, and the width, by the construction of the cell and the diaphragm, to about 2 feet, and the anode current density being limited for reasons of satisfactory corrosion and economy of power, at about 10 ampères per square foot, the solution which should be drawn from every compartment is, in an hour's time, a comparatively small quantity. One liter per hour is a rate found desirable, and for a uniform flow of this amount requires a very small opening in the discharge tube. On account of the difficulty of entirely preventing the formation of insoluble particles in the solutions, these openings gave a great deal of trouble from clogging, requiring constant attention until another method of regulating the discharge was devised, which is shown in the adjoining figure.

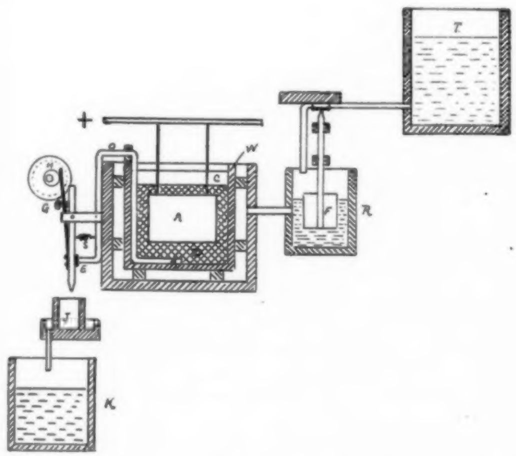
Instead of regulating the flow by the size of the opening of the siphon *o*, the opening is made large enough to allow any precipitated particles to readily pass through. This outlet, normally closed by a piece of rubber pressing against it by spring *s*, is opened periodically by an eccentric *H*, rotating at a fixed speed. The quantity of solution drawn off is regulated by adjusting the screw *G*. This method of regulation proved satisfactory, and may be advantageously used in various other electrolytic processes. It was found that in the operation of a solution of sodium nitrate, having a specific gravity of 1.12, 0.6 per cent. of free nitric acid was desirable to insure satisfactory anode corrosion. This free acid can be introduced either in the stock solution flowing between the two dia-

phragms or directly into the anode solution. In the former method there is more uniform distribution of this acid than in the latter, but where the stock solution is acidified there is involved the disadvantage that more acid is required by some of it going into the cathode compartment, and thereby being neutralized. To overcome this disadvantage, a third diaphragm may be introduced, so that the stock solution is now supplied to two compartments, that flowing into one compartment being acidified to the proper amount and that flowing into the other being neutral.

The authors describe a small laboratory plant for the corrosion of lead. The electrolytic tank has three anode and four cathode compartments, and is capable of corroding about 10 pounds of lead per twenty-four hours. For the illustrations and diagrams representing the apparatus, the reader must be referred to the full paper, which will be presented in the Transactions of the Society.

By the method of the authors continuous operation can be effected with high percentage of corrosion, no clogging of diaphragms and uniformity of composition of solution running from the cell. The e. m. f. found necessary is about 1.4 volt, representing an expenditure of energy of 0.22 horse-power hour per pound of lead corroded.

Various methods of procedure may be followed in utilizing this apparatus for commercial purposes. A method of manufacturing white lead from such solutions, which has been extensively described in the literature, consists in mixing these two electrode solutions to form a lead hydroxide, and thereby a "regeneration of the original solution." The precipitate of lead hydroxide thus formed was treated by CO_2, either from the air or generated chemically, changing the precipitate to a lead carbonate, which is the useful white pigment. Analysis of the cathode solution, however, shows that the claim of "regenerating the original solution" cannot be realized, on account of the formation of ammonium and nitrite compounds. An analysis of the cathode solution on one run showed the following content per liter: 25. g NaOH, 3.52 g NH_4OH, 0.165 g $NaNo_2$, 54.3 g $NaNO_3$. A similar analysis of the anode solution showed a content per liter of 113.5 g Pb $(NO_3)_2$ and 57.6 g $NaNO_3$.



REGULATING THE DISCHARGE FROM ELECTROLYTIC APPARATUS.

The anode solution might be used to advantage for the manufacture of lead nitrate by fractional crystallization, but to do so requires the recovery of the values in the cathode solution, and it is upon this point that commercial success depends. By heating to a boiling temperature, the ammonia can be driven off and recovered, but the separation of the nitrite, the nitrate and the hydroxide cannot be readily accomplished.

In all methods for the production of metal compounds from a sodium nitrate electrolyte, the question of commercial success seems to depend upon the suitable treatment of the cathode solution, either by separating the materials or by finding uses for the solution as it comes from the electrolyzing tank. If the sodium nitrate fed into the electrolyzing tank could be completely utilized, the problem of the treatment of solutions could be considerably simplified. But, in order to keep the electrode products completely separated in the electrolyzer, it was found desirable to run the solutions at such a rate that about one-half the sodium nitrate passes through without undergoing electrolysis.

Some of the disadvantages attendant upon the use of sodium nitrate as the electrolyte material can be avoided by the use of sodium acetate. The amount of alkali produced at the cathode is equivalent to the lead acetate formed at the anode, and the chemical reactions are therefore simpler. The relative advantage of the acetate is, however, not determined by this factor alone. The cost of sodium acetate is much greater than the nitrate, calling for great care in the prevention of waste from leakage and washing the precipitate. The acetate requires to be used in a considerable degree of purity, while the ordinary commercial grade of sodium nitrate is sufficiently pure. The voltage necessary is considerably higher, and the difficulty of clean anode corrosion is decidedly against the acetate.

The experiments here described were carried out in an attempt to test on a laboratory scale various processes which have been described for the production of white lead. In this work, which was carried on for several months, the authors have found that it is entirely possible to produce a white lead in exactly the same composition, as far as the relative amount of hydroxide and carbonate of lead are concerned, as in the old Dutch process. The physical properties can also be duplicated. The conclusion seems to be justified, however, that there is little chance for the electrolytic process replacing the chemical methods for the production of this useful pigment, at least along the lines referred to. From the present market values of pure lead and the white lead made therefrom, it is seen that there is very little margin to pay the cost of the electrical energy, the necessary losses in the electrolyte, the cost of casting the lead into shape suitable for anode purposes, labor and depreciation of the electrolytic tanks and leave anything for a profit.

In the production of various other lead compounds, however, there seems to be greater opportunity for commercial application of the electrolytic method. The acetate of lead may be produced in a manner similar to that suggested for the production of the nitrate. Lead chloride may be produced from the electrolysis of a hot sodium chloride solution, lead chloride separating out on cooling. Lead chromate, which is a pigment used in large quantities, can be made by precipitating the anode solution by means of sodium bichromate, and thereby regenerating the original solution and furnishing the free acid necessary for the giving of uniform corrosion of the lead anode.

It will be noted that in all of the proposed processes for the electrolytic production of metallic compounds electricity plays only an incidental and sometimes very minor part in the operation. There are undoubtedly many places where the electrolytic step might be advantageously introduced into present purely chemical operations. Not only may the electrolytic effect of the current be utilized, but the heat effect may also be employed. A process for the production of metallic compounds utilizing the heat properties of the current consists in volatilizing the metal either in a resistance or arc furnace, and exposing the vapors or the fine metal particles thereby produced to the action of chemical reagents, which will produce the desired chemical compound. The controlling factor in this case is the cost of electrical energy, the amount of energy required to treat a pound of metal in this way being much greater than in the electrolytic methods.

THE ELECTRODEPOSITION OF METALS ON ROTATING CATHODES.

At the New York meeting of the American Electrochemical Society a paper, by MR. J. G. ZIMMERMAN, was presented which should be of considerable interest from the practical standpoint. The author not only shows the possibility of nickel plating in one minute, instead of one hour, as is common practice, but he also shows that it is possible to deposit the nickel in such a manner that the subsequent buffing operation is avoided. It will be remembered that some time ago there was a considerable discussion in English journals as to whether the smoothness of the coating was due to centrifugal effect or to the friction of the solution. The present paper seems to show that it is due to the friction effect alone. In the following we give an abstract of Mr. Zimmerman's paper:

The use of high current densities in depositing metals is made possible by the use of rapidly-rotating cathodes, and an investigation of this subject has been carried out in the Applied Electrochemistry Laboratory of the University of Wisconsin. The method of investigation consisted of rotating a brass tube, ⅞ inch in diameter, attached directly to the shaft of a small electric motor, and in varying the speed, current density and composition of the electrolyte.

It was found that the rotation enables the current density to be run up to a very high value. At the comparatively low speed of 700 revolutions per minute and a current density of 200 ampères per square foot, a very good deposit of nickel, up to a thickness of about .04 inch, was produced. In the case of copper this thickness was increased to about .25 inch, and after that the cathode assumed a rough, pebbly appearance, the roughness increasing rapidly, until finally the higher elevations grew out in the form of trees, which pointed in a direction opposite to that of the rotation.

It was observed that the critical current density, *i. e.*, the current density at which a powdery deposit occurs, is approximately proportional to the speed of rotation. The highest speed which was used, however, was 2,500 revolutions per minute, corresponding to a velocity of 575 feet. The observations here made tend to confirm the statement of Mr. Cowper-Coles,* that if a peripheral velocity of 1,000 feet per minute and current density of 200 ampères per square foot be used, the copper will plate out with a high polish and to any thickness desired. The copper solution used was a nearly saturated solution of the sulphate with 10 per cent. of free sulphuric acid.

The depositing of nickel upon the rotating cathode revealed some interesting effects. While the ordinary current density used for nickel plating is about 6 ampères per square foot, it was found possible, at a rotation of 1,000 revolutions per minute, to run the current density as high as 300 ampères and still obtain excellent deposits of nickel. The ordinary double-nickel ammonium sulphate solution was used. When first used in the solution, the deposit was of a dull-white mat appearance. After operating the solution for some time, it was found that the deposit acquired a very high polish, comparable to that which is ordinarily obtained by means of a buffing wheel. From the fact that the anode failed to corrode in accordance with the amount of current, it was thought that this polished coating was the result of the solution becoming somewhat acid. By the addition of a small amount of free acid to the ordinary plating solution the character of the deposit was entirely ruined, and just what factors the polish depends upon has not been definitely determined.

It was found that it is possible to obtain a much thicker coating of nickel when the cathodes are rotated than when stationary, and, under suitable conditions, the deposition may proceed indefinitely without causing the metal to crack or break away from the surface. The increase of acidity, dilution and temperature of the electrolyte increases the tendency for the deposit to break up.

When portions of the deposited nickel became loose and curled away from the surface, they protected the space directly back of them from friction with the electrolyte, and as a consequence that part of the cathode received a dark, powdery deposit similar to the familiar "burned" appearance of nickel. On the other hand, the surfaces exposed to the friction of the solution were highly polished, and the unusual appearance of nickel trees was shown on the extreme edge.

The behavior of zinc is far different from that of nickel when deposited upon rotating electrodes. While it is difficult to obtain rough and tree-like deposits of nickel, it is very difficult to prevent them in the case of zinc. Zinc can be deposited in a smooth state only by adopting special precautions. One of these is to increase the friction of the solution against the metal through the aid of partition in the cell, which prevents the electrolyte from taking up a circulatory motion to correspond with the cathode. The closer the edge of this partition is brought to the cathode the smoother is the deposit. The tendency is for the zinc to be deposited in ridges, and the height and width of these ridges is inversely proportional to the amount of friction of the electrolyte. The solution which was used was a zinc-plating solution, such as is ordinarily used for electrogalvanizing, consisting of zinc and aluminium sulphate. It was found impossible to use as high a current density with a given speed of rotation as is possible with either copper or nickel.

Increase of current density was also shown to be possible in the deposition of iron, lead, antimony and silver.

* Jour. of Inst. of Elect. Eng., Vol. XXIX, 1900.

INSULATING MATERIALS A FIELD FOR CHEMISTS.

In a paper with this title, read by DR. MAX VON RECKLINGHAUSEN at the New York meeting of the American Electrochemical Society, the author points out how the development of electrical engineering has made possible the recent progress in industrial electrochemistry. The electrochemist is therefore under the greatest obligations to the electrical industry, and it is only fair that he should show his gratitude by helping the electrical engineer out of his troubles in a field where chemical research is of vital importance, *i. e.*, in the field of electrical insulating materials.

Chemists in general do not appreciate sufficiently the enormous value which chemical work in this field would have for the advance of the electrical industry. Moreover, they generally do not appreciate the different wants of the electrical engineer. It happens over and over again that chemists offer materials for insulation which may have one good property, but lack others, which may, for instance, have enormous insulating resistance to passage of current, but be so highly inflammable or so low melting as to be utterly useless for the purpose intended.

The author first classifies the important properties of insulating materials, as follows:

First. Electrical Properties.—(a) Insulation resistance or conductivity, expressed in ohms per cubic centimeter; (b) disruptive or dielectric strength, measured by the potential necessary to puncture the material; (c) dielectric constant, or specific inductive capacity, measured by the capacity in microfarads of a condenser having the particular material as dielectric, separating the metal plates. This last-named property is less important than the two preceding.

Second. Mechanical Properties.—(a) Strength and workability (in case of solids); or (b) flexibility and workability (in case of semi-solids); or (c) viscosity (in case of liquids).

Third. Chemical Properties.—(a) Combustibility; (b) property of resisting the influence of moisture (hygroscopic quality), air, oil, acids, etc.

The factors which may considerably influence the properties of the insulating materials during use are the following: First, rise of temperature (sometimes going so far as to melt or char organic materials); second, mechanical stress, resulting

in change of shape or breaking; third, chemical action, as of water, oil, ozone, nitrous fumes (which may be generated by brush discharges near-by), or gases and fumes developed by factory processes in the neighborhood of the electrical apparatus.

Desirable qualities are, mainly, good insulation resistance, high disruptive strength and fair mechanical properties, especially workability. Undesirable are, mainly, combustibility and changes in the electrical and mechanical properties with rise of temperature or with age, and, of course, high price.

To chemically classify the insulating materials, it is practical to consider them under the headings of: I. Organic materials, liquid and solid. II. Mixtures of organic and inorganic materials. III. Inorganic materials.

Liquid Organic Materials.—These comprise the materials used mainly for transformer insulating and cooling, for condensers and more recently for circuit breakers. Such liquid insulators are the different oils and other liquid organic compounds. Most properties of the oils as used now are desirable. The worst feature inherent to them is their combustibility. The flash test and the viscosity test (and influence of long-continued use on the same) give a good idea of the usefulness of an oil for the purposes mentioned above. In the case of circuit breakers, as well as of transformers, where accidental high potential may have arced through the oil, the broken-down oil insulation should soon be repaired and the oil should come back to its original insulating power; at the same time it would be good that such oil does not develop too much of low-flash products, which bring with them the danger of fire. In circuit-breaker work some oils will break the arc off very sharply, with corresponding back effect on inductance in the line; others will be slower in their action, and may thus be more useful for such purposes. Naturally, one has to study the effect of the oils on the different materials they come in contact with. Fatty acids seem to be undesirable in such respects, because they are apt to react with copper.

To do away with the worst feature of oils, their combustibility, it has been proposed to use halogen carbon compounds instead of hydrocarbon compounds. It is distinctly worth investigating whether the products resulting from such liquids when the discharge goes through would be of too bad an effect on the apparatus. For instance, tetra-chloride of carbon would probably break up into carbon and free chlorine, and the latter would very likely injure the metal.

Organic Compounds Used as Solids of More or Less Plastic State.—Typical representatives of this long line are the different varnishes, lacquers, drying oils, rubber, compounds made from blood, glue, all the different cellulose materials, such as for textile fabrics, wood and mixtures of the different materials belonging to this group. It will be rather hard work to make material advance in this field by further research, as the makers of these materials are on the outlook for improvements for some time.

The author points out some of the disadvantages of the materials used nowadays. Many of them lose their mechanical strength and their insulating power and dielectric strength by age, and by short or long duration of high temperature and high electric stress. All of them are more or less inflammable. Here is probably the point where thorough chemical research could find its field. The pure cellulose compounds are probably very good in every regard, especially because they seem to be less affected by heat and less inflammable than the other materials of this group; but up to now they are fairly difficult to get into the desired dense mechanical shape. Nitro-cellulose and other celluloid compounds are ideal in this way, but, of course, are out of the question on account of their combustibility. New artificial masses, such as viscose, cellulose made out of cellulose solution in acids, metal salts, etc., and similar products may very well be worth experimenting with, because they are free from nitro-groups, and therefore are probably little affected by heat. Also glue and gelatine compounds, made insoluble by different methods, ought to be examined for their usefulness as insulators and, if necessary, chemically modified, so as to compete successfully, in properties and price, with materials used now.

One point is important for dynamo, and especially transformer insulation, *i. e.*, that the oil used should not have a dissolving or other injurious effect on the insulating material. Furthermore, the insulation should not be affected by moisture, which often in large amounts covers cold apparatus brought into warm rooms. Complaints are heard of attack of some varnishes on wires, particularly thin wires. For such purposes it may be good to prevent direct contact of the varnish and the metal by an intermediate coating.

Attempts are being made lately to produce asphalt compounds, which seem to have many excellent properties. Still, it will be fairly hard to find materials electrically and mechanically desirable but unaffected by oil and water. The author briefly refers to the old problem of finding a substitute for the expensive gutta percha.

Mixtures of Organic and Inorganic Materials.—Typical representatives of this group are materials made of asbestos or mica with varnish, rubber or paper, or similar materials out of the group mentioned before. The asbestos compounds, as a rule, lack high insulating power, also mechanical strength. The mica papers lack great flexibility and homogeneity.

Inorganic Materials.—The representative materials of this group are slate, marble, asbestos, porcelain and glass. They are, of course, practically unaffected by heat, but lack entirely flexibility, and are, furthermore, fairly expensive to form into the desired shapes. Better in the latter regard, but not so good insulators, are cement-like mixtures made out of water, glass and asbestos, or similar materials. Progress in this field may be expected in the line of the castable cements, although up to now they seem to be too hygroscopic.

That even the mineral insulators become conductors at high temperatures has been found out by people working on the Nernst lamp, where, after finding a good conductor at high temperature for the glower part, they had great trouble to find a good insulator, at high temperatures, for the heater part.

The main objection to marble for switchboard work is the great expense. Anything to replace marble would be of greatest importance. It should, of course, not be hygroscopic at all. Some time ago this was found to be important for high-tension line insulators, so that the makers were careful to make insulators absolutely non-hygroscopic by choosing glass free from alkali. Still, the beneficial effect of this is, to a certain extent, overrated, as the heat developed by the leakage current is enough to remove the water which may condense on the insulator.

The paper is concluded by the remark that a tremendous step forward for the electrical engineer would be an insulating material of the flexibility of asbestos and the ideally high insulating and dielectric strength of mica.

IONS AND ELECTRONS.

A paper on this highly interesting and timely subject was presented, by Dr. Louis A. Parsons, of the Johns Hopkins University, at the recent New York meeting of the American Electrochemical Society. In the following we give an abstract of this paper:

Soon after the construction of the first galvanic batteries water was decomposed into oxygen and hydrogen. Later Sir Humphrey Davy, with the great battery of the Royal Institution, decomposed soda and potash, both of which had been considered as elementary substances. And it was early found that whenever an electric current is passed through a solution of any acid, base or salt, decomposition occurs, and the elements or compounds formed appear at the electrodes. From this the idea was conceived of the dissociation or breaking down of the molecules of a substance into charged constituent parts. Faraday gave to these charged parts—atoms or groups of atoms—

the name of ions. According to the electrolytic dissociation theory—proposed by Clausius in 1856, and modified and given in its present form by Arrhenius—whenever a substance is dissolved a certain proportion of the molecules of the dissolved substance (depending on the concentration of the solution) are dissociated, so that the electromotive force acts as a directive force upon these dissociated ions, moving them in the direction of the oppositely-charged electrodes. Many recombinations and subsequent dissociations may occur in the passage to an electrode, and, as ions are removed from solution at the electrodes (by the formation of insoluble compounds), more molecules are dissociated, so that a sort of dynamical equilibrium is maintained.

The ratio of the mass of an ion to the electric charge carried by it is, according to Faraday's laws, a constant for any one substance, and is proportional to the chemical equivalent of that substance. Hence the charge carried by an ion is proportional to its valence. The charge carried by a hydrogen ion has been calculated to be of the order of 10^{9} electrostatic units (10^{19} coulombs).

The passage of electricity through gases at very low pressures gives rise to the cathode rays. These rays travel in straight lines; produce intense heating of solid objects against which they strike; cause fluorescence in many bodies acting as targets; are deflected by electrostic and by magnetic fields of force, and, when passed through metallic cylinders, induce electric charges on them. In short, they act exactly as theory shows negatively-charged particles, projected from the cathode with great velocities, would act. Upon the assumption that they were negatively-charged particles, J. J. Thomson calculated from the magnetic and electrostatic deflections (and also another method) both the velocity and the ratio of the mass of the carriers to their charge. The velocity came out different in different cases, but was of the order of one-tenth the velocity of light, while the ratio of m to e was the same in all cases, not being a function of the gas, as in the case of ordinary electrolysis, and was only about one-one thousandth as great as in the case of a hydrogen ion in electrolysis. By other experiments it was found that the charge e was the same as the charge on a hydrogen ion in electrolysis. Hence the mass must be about one-one thousandth of the mass of a hydrogen atom. These small bodies concerned in all electrical discharges Thomson called *corpuscles*. In a tube giving cathode rays there are other rays, consisting of positively-charged bodies of the same mass as ions in electrolysis. These experiments suggested to Thomson that "negative electricity consists of the corpuscles . . . and that positive electrification consists in the absence of these corpuscles from ordinary atoms." This leads to a new theory, covering all electrical phenomena, including, of course, electrolysis. According to this theory, an uncharged atom or molecule is one having connected with it a corpuscle (or enough corpuscles to neutralize it). Ionization consists in the separation of the corpuscle from the atom. In gases at low pressure the negative ion is the corpuscle, the positive ion the atom or group of atoms, which have lost a corpuscle (or more). In solution the corpuscle does not remain free, but is attached to an otherwise neutral atom (or group of atoms).

Some, including Lord Kelvin and Oliver Lodge, have gone further than this, and suggested that the cathode rays are moving electric charges entirely divested of matter. These elementary charges—always negative—are, as it were, "atoms of electricity," and are known as *electrons*.

According to the electron theory, a neutral atom or molecule is one with "the neutralizing quantum of electrons," as Kelvin expresses it. Ionization is explained similarly to Thomson's explanations for corpuscles. The cathode rays consist of free electrons and the canal rays of atoms which have lost electrons. All electric conduction consists in the motion of electrons. In gases at low pressure we have what Lodge calls the "shot method"—the electrons are projected from the cathode like shot from a gun. In liquids and gases under pressure, the "bird-seed method," the electrons are attached to the atoms, and are, as it were, carried a short distance and then dropped. And in metals the "fire-bucket method," where the electrons are handed on from one atom to the next. Magnetism is explained by the motion of electrons, which take the place of the ampère currents.

A moving electron is surrounded by a magnetic field and an electrostatic field, and may be deflected by either one produced by an external source. When its motion is accelerated there is a radiation of energy through the ether. When the electron is abruptly stopped by a target, an electromagnetic pulse goes out through the ether with the velocity of light, and such pulses constitute the X rays. Centrifugal acceleration produces radiation also. If the electron is revolving in an orbit with constant speed, a continuous train of waves will be given out. These waves constitute ordinary light if the period of revolution of the electron is comprised within the limits of periods for the visible spectrum. There may be many electrons connected with a single atom or revolving inside the atom, each having its own period of vibration, thus producing many lines in the spectrum of an elementary substance. If a magnetic field is produced, so as to pass through the orbit of the electron, it will either accelerate or retard the speed. The doubling of the lines results, and the Zeeman effect is easily explained on this basis. The Aurora Borealis has been explained as due to the passage through our upper atmosphere of electrons, coming perhaps from the sun, following the lines of the earth's magnetic field.

All substances seem to spontaneously give off electrons, but some—the radioactive substances—give them off at a vastly greater rate than others. The emission of these electrons constitutes the Becquerel rays.

The mass of an electron (*i. e.*, its inertia) is, as has been said, about one-one thousandth of the mass of a hydrogen atom (about 10^{28} gm). That is, it bears about the same relation to the mass of a gram weight as the gram does to the mass of the earth. The theory of the motion of an electrically-charged sphere gives for the value of the inertia of the electrification equal to two-thirds the square of the charge, divided by the radius of the sphere. It is interesting to calculate the diameter of an electron on the assumption that it is a sphere, and that this equation holds. Taking the best values, we find the radius of the electron to be between 10^{13} and 10^{12} centimeters. The radius of a hydrogen atom has been calculated to be about 10^{8} centimeters. Hence the radius of an electron is one-ten thousandth or one-one hundred thousandth of that of an atom, or about the ten millionth or one hundred millionth part of a wave length of light. If dimensions were so magnified that a wave length of light would extend from Baltimore to New York, an electron would be about as large as a bullet or marble. Magnified the same, a foot-rule would cover the distance from the earth to the sun. If an atom were magnified until it were a globe 100 feet in diameter, an electron would be about the size of the dot on a letter *i* on a printed page.

J. WILLARD GIBBS.

J. Willard Gibbs, who died suddenly, of heart disease, at his residence, in New Haven, Conn., on April 28th, was born in New Haven, February 11, 1839. He entered Yale College in the autumn of 1854, receiving the A.B. degree in 1858 and the Ph.D. degree five years later, in 1863. Three years were spent in Europe in the study of physics, at Paris, Berlin and Heidelberg. In 1871 Dr. Gibbs was appointed professor of mathematical physics at Yale, and he held this chair until his death. An offer of a chair at the Johns Hopkins University was declined.

The published works of Professor Gibbs include:

Graphical Methods in the Thermodynamics of Fluids. Trans. Conn. Acad., Vol. II (1873).

A Method of Geometrical Representation of the Thermody-

namic Properties of Substances by Means of Surfaces. Trans. Conn. Acad., Vol. II (1873).

On the Equilibrium of Heterogeneous Substances. Trans. Conn. Acad., Vol. III (1876-1878).

On the Vapor Densities of Peroxide of Nitrogen, Formic Acid, Acetic Acid and Perchloride of Phosphorus. *Am. Jour. Sci.* (3), Vol. XVIII (1879).

Two letters on Electrochemical Thermodynamics. Reports British Asso. Adv. Sci., 1886 and 1888.

Semi-permeable Films and Osmotic Pressure. *Nature*, 1897, March 18th.

Notes on the Electromagnetic Theory of Light:

I. On Double Refraction and the Dispersion of Colors in Perfectly Transparent Media. *Am. Jour. Sci.* (3), Vol. XXIII (1882).

II. On Double Refraction in Perfectly Transparent Media which Exhibit the Phenomena of Circular Polarization. *Am. Jour. Sci.* (3), Vol. XXIII (1882).

III. On the General Equations of Monochromatic Light in Media of Every Degree of Transparency. *Am. Jour. Sci.* (3), Vol. XXV (1883).

On the Velocity of Light as Determined by Foucault's Revolving Mirror. *Nature*, Vol. XXXIII, 582 (1885).

Elements of Vector Analysis, arranged for the use of students in physics. (Privately printed in 1881.)

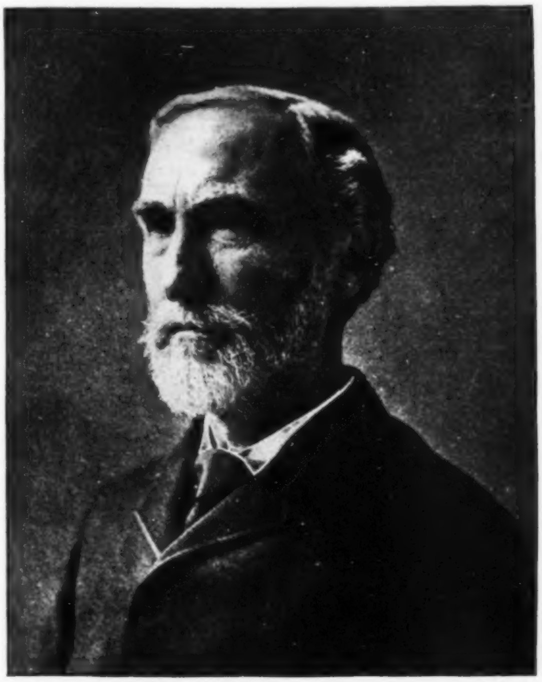
Multiple Algebra. Proc. Am. Asso. Adv. Sci., 1886. (Address as vice-president of the Section for Mathematics and Astronomy.)

On the Determination of Elliptic Orbits from Three Complete Observations. Mem. Nat. Acad. Sci., Vol. IV.

Letters to *Nature*, Vols XLIII and XLIV (1891); Vol. XLVIII (193), on Vector Analysis, Quaternions and the Ausdehnungslehre.

Elementary Principles in Statistical Mechanics. Yale Bi-centennial Publications.

Vector Analysis. Founded upon the lectures of J. Willard Gibbs. By E. B. Wilson. Yale Bi-centennial Publications.



J. Willard Gibbs

Professor Gibbs was elected a member of the National Academy of Sciences (Washington) in 1879; associate fellow of the American Academy of Arts and Sciences (Boston) in 1880; foreign member of the Dutch Society of Sciences (Haarlem) in 1886; correspondent of the Royal Society of Sciences (Göttingen) in 1889; honorary member of the Cambridge Philosophical Society in 1891; honorary member of the London Mathematical Society in 1892; foreign member of the Royal Academy of Sciences (Amsterdam) in 1892; foreign member of the Royal Society (London) in 1897. Professor Gibbs received the honorary degree of Ph.D. from the University of Erlangen in 1893; of LL.D. from Williams College in the same year, and of LL.D. from Princeton College in 1896. In 1880 the Rumford medal was awarded to him by the American Academy of Arts and Sciences for researches in thermodynamics.

Personally, Mr. Gibbs was a retiring, warm-hearted man, loved by all who were privileged to know him. He was always ready to furnish information to fellow-workers, even when the appeals came from people whom he had never met, and even when the questions were in themselves foolish ones. I shall never forget the time and pains expended in making clear to me the errors into which I had fallen.

Dr. Gibbs was great as a pure mathematician, as a mathematical physicist and as a mathematical chemist. His work as a mathematician has received more immediate recognition and has had more positive influence than his work in chemistry, but it is probable that this is because he found a more intelligent audience among mathematicians than among chemists. Although the paper on "The Equilibrium of Heterogeneous Substances" was deemed worthy of the Rumford medal in 1880, two years after publication, this does not imply that the paper was understood then or now. It is not accessible as a separate publication in English to this day. A German translation has been made by Ostwald. Part of the paper has already been translated into French by Le Chatelier, and the balance is to appear shortly.

The attention of Roozeboom was called to Gibbs' paper by van der Waals, and what was condensed into a few paragraphs by Gibbs has been expanded into the phase rule by Roozeboom, and bids fair to become the basis of classification for the whole of chemical science.

The first general recognition of the importance to chemistry of this paper by Gibbs dates from the publication of the German translation by Ostwald, in 1892, and is due largely to Ostwald's enthusiastic statements in regard to the quality of Gibbs' work. While the fundamental importance of this paper is now generally recognized by chemists, it must be admitted that this is very largely lip service still. There is no man who pretends to understand Gibbs. There are some who have mastered small portions of this classical work, but that is all. As one distinguished scientific man has said, it is easier to discover a thing one-self than to find it in Gibbs. This is perfectly true. But when one has, after much effort, discovered a thing, one finds it all in a more general form in Gibbs. The trouble is not that Gibbs is obscure. After one has mastered a small portion, one wonders that there should ever have been any difficulty in understanding that particular passage; but the difficulty reappears with the next passage. Gibbs' mind works along different lines from those of the chemist of to-day, and the latter cannot follow. We all know that Faraday's reasoning seemed obscure until Clerk-Maxwell put it into mathematical form. When some experimental chemist succeeds in doing for Gibbs' mathematics what Clerk-Maxwell did for Faraday's experiments, then for the first time shall we appreciate the real greatness of the man whose loss we mourn.

WILDER D. BANCROFT.

NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The third general meeting of the American Electrochemical Society, held at New York City, from April 16th to 18th, scored the success which had been expected. The enthusiasm and good-fellowship of the members of the vigorous young Society—both the engineers and the scientists—have in no way abated. This is the most important point. On the other hand, for the success of the New York meeting as a social affair, not enough credit can be given to the untiring efforts of the local New York committee, with Dr. C. A. Doremus as chairman and Mr. Alois von Isakovics as secretary. The programme, as outlined in the last two numbers of ELECTROCHEMICAL INDUSTRY, was carried out successfully, and, to give due credit to whom credit is due, we may here quote the resolution offered by Dr. Bancroft at the end of the meeting and accepted unanimously: "That a hearty vote of thanks should be extended to the Chemists' Club, through whose hospitality our meeting has been made possible; to the German Liederkranz for throwing open the doors of its palatial club house; to our sister society, the American Institute of Electrical Engineers, for the pleasure given us of the joint meeting; to the various owners and superintendents of establishments and plants which we have been privileged to visit; to the local committee for its Herculean effort in our behalf. The magnificent results of their work have been visible to and appreciated by all of us, and we know what co-operation and organization must have been necessary to insure for us the most successful meeting of the Society."

BUSINESS MEETING.

The meeting on April 16th was called to order by Dr. C. A. Doremus, chairman of the New York local committee. Dr. Wm. McMurtrie extended the hospitality of the Chemists' Club to the Society in some well-chosen words. He said that the Chemists' Club had been founded to become the center of the chemical activity of this country, and should be regarded as the headquarters of all chemists who visit New York. President J. W. Richards replied, and extended the thanks of the American Electrochemical Society to the Chemists' Club for the courtesies extended.

The official reports of the secretary and treasurer were then read. Mr. C. J. Reed, as secretary, reported that the Society has at present 492 members, and that this number will increase to 512 at the next election of new members by the Board of Directors. Mr. Reed also suggested that while it may still appear to be too early now to do anything towards the establishment of local branch organizations, yet at the present rate of increase of members such local branches may very soon become desirable, if not a necessity. Mr. Reed referred to the excellent results achieved by the American Institute of Electrical Engineers with this plan, and expressed the opinion that local branch organizations in the cities with a large membership list would be able to contribute materially to the value of the Transactions. Some kind of co-operation with European electrochemical societies was suggested, if possible, in such a way that the different societies supply the members of the other societies with their publications at a reduced rate.

From the report of the treasurer, Mr. P. G. Salom, it appears that the financial conditions are extremely good, in consideration of the comparatively very low membership fee.

The business meeting was then adjourned. It was again taken up in the Friday morning session, when the tellers, through Prof. G. W. Patterson, announced the results of the election of officers. The present constitution of the Board of Directors has not been changed; Dr. J. W. Richards was re-elected president; Mr. C. J. Reed, secretary; Mr. P. G. Salom, treasurer; Dr. W. D. Bancroft, Dr. C. A. Doremus and Dr. W. R. Whitney, vice-presidents, and Col. S. Reber, Dr. S. P. Sadtler and Mr. C. O. Mailloux, managers.

The vote in detail was as follows: For president—J. W. Richards, 160 votes; A. H. Cowles, 35; E. G. Acheson, 9; W. D. Bancroft, 5, and some scattered votes. For vice-president—W. D. Bancroft, 147; C. A. Doremus, 145; W. R. Whitney, 119; A. H. Cowles, 50; C. E. Acker, 27; Carl Hering, 19; E. G. Acheson, 18; C. F. Burgess, 17; C. S. Bradley, 11; C. P. Steinmetz, 10; R. M. Thompson, 8, and some scattered votes. For managers—S. Reber, 150; S. P. Sadtler, 137; C. O. Mailloux, 134; C. F. Burgess, 20; C. E. Acker, 18; C. P. Townsend, 16; F. B. Crocker, 15; W. D. Bancroft, 12; C. A. Doremus, 10; T. Wolcott, 10; F. J. Tone, 10. For secretary and treasurer, C. J. Reed and P. G. Salom received 210 and 204 votes respectively.

The president then announced the generous offer made by Mr. A. B. Frenzel, Denver, Colo., who proposes the award of $250 for the best paper on the treatment of rare metals, such as molybdenum, vanadium, thorium, tungsten, etc. Mr. Frenzel, whose offer was accepted by the Board of Directors, will supply engineers who intend to take up this problem with any reasonable amount of ore necessary for the investigation, f. o. b. Denver. The award of the prize will be made by the Board of Directors of the Society.

The number of members and guests who registered at the meeting was 260. An alphabetical list of all who registered is found on another page of this issue. Among the foreign guests of the Society were Dr. Walter Nernst, the famous professor of electrochemistry of Goettingen, Germany; Dr. Bussmann, superintendent of the Nernst lamp department of the Allgemeine Elektricitäts Gesellschaft, Berlin, Germany; Dr. A. Franke, director of the Siemens & Halske Co., Berlin, Germany, and Dr. Reisnegger, chemist of Meister, Lucius & Bruening, Augsburg, Germany.

The morning and afternoon of Thursday, the morning of Friday and the morning of Saturday were devoted to the reading and discussion of papers, a full report of which will be found below. For the afternoons of Friday and Saturday visits to places of interest had been arranged, the list including the works of the Sawyer-Man Electric Co., a special exhibit of electrochemical apparatus by Eimer & Amend, the laboratories of the Cooper Union Institute, the Willyoung & Gibson Co., the Crocker-Wheeler Electric Works, a galvanizing plant installed at the Brooklyn Navy Yard by the United States Electro-Galvanizing Co., the Edison station at Thirty-eighth street, the Manhattan Railway Co's power house at Seventy-fourth street, the Metropolitan Street Railway Co's power house at Ninety-sixth street, the new Rapid Transit Tunnel at Fifty-ninth street and Broadway, Columbia College and the New Jersey Zinc Works.

On the evening of Thursday a reception and a subscription banquet was held in the handsomely-decorated hall of the German Liederkranz Society. It proved to be the most notable social feature of the convention. The after-dinner speeches were greatly enjoyed. Dr. C. A. Doremus acted as toastmaster, and the following toasts were responded to: "America, the Electrochemical Center of the World," by Dr. J. W. Richards; "Development of Electrochemical Theories," by Dr. Walter Nernst; "The American Institute of Electrical Engineers," by Mr. C. F. Scott, president of the American Institute of Electrical Engineers; "The American Chemical Society, by Dr. C. F. Chandler, of Columbia University, and "Kitchen Chemistry," by Dr. H. W. Wiley, chief of the United States Department of Agriculture. Mrs. Anna Eisen, soprano, and Mr. Carl Schlegel, baritone, received much applause for several songs, Dr. G. Drobegg accompanying them with much art on the piano.

On Friday evening a joint meeting of the American Electrochemical Society and the American Institute of Electrical Engineers was held in the chapel of the College of the City of New York. President Scott, of the Institute, made some introductory remarks, and then Mr. Hammer read an excellent paper, an account of which will be found below.

On Saturday evening Dr. J. W. Richards delivered his excellent presidential address, a long abstract of which will be found elsewhere in this issue. Afterwards Mr. P. H. Thomas exhibited the Cooper-Hewitt rectifier. Alternating current

was converted by its means to direct current for lighting lamps and running a direct-current motor. Dr. M. von Recklinghausen then exhibited the Cooper-Hewitt mercury lamp, and dealt especially with the actinic properties of the light. Some photographs of groups of members and guests, taken with the Cooper-Hewitt light after Dr. von Recklinghausen's lecture, are reproduced below. The official programme was then concluded by a German-American smoker ("Kneipe"), which was greatly enjoyed. Dr. Richards spoke of his college days in Heidelberg and Freiberg, and Dr. McMurtrie, Dr. Doremus, Dr. Keith and others told many entertaining stories. The affair was indeed so enjoyable that, after the smoker was over, most of the members present concluded that it was still too early to adjourn *sine die,* and started another unofficial session in the hospitable hall of the Liederkranz.

A complete report of the papers and discussions is given below.

CONSTANT VOLTAGE AND CONSTANT-CURRENT SEPARATIONS.

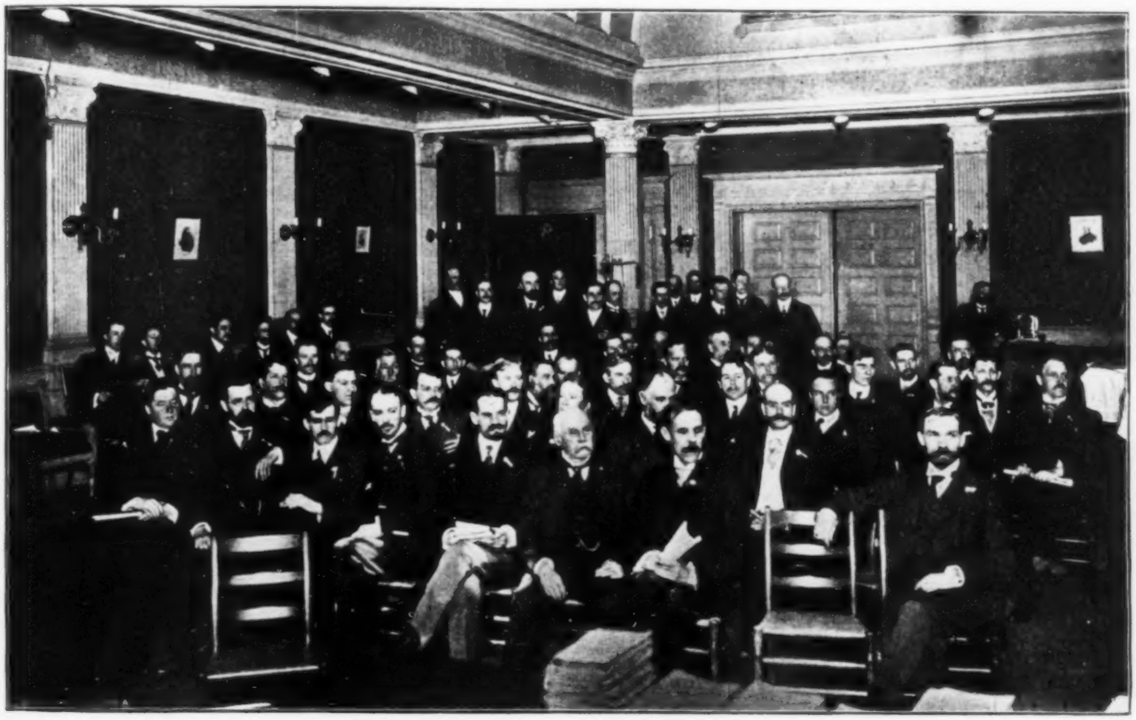
The paper by DR. W. D. BANCROFT, of Cornell, on this subject had for its purpose the establishment of a general rule of classification for the numerous methods given in text-books on electro-analysis. There are used in electro-analytical practice two essentially different methods for separating metals from other metals. In one method the voltage is kept constant, in the other the current. Dr. Bancroft showed the conditions which determine whether the one or the other method is to be used.

Since the electrolytic separation of two metals depends on the fact that one precipitates at a lower voltage than the other, it would seem as though the proper way to effect a separation is to hold the voltage at a value high enough to precipitate the one metal, but too low for the precipitation of the other metal. By using this method the current gradually decreases, and drops to a very low value as soon as the first metal is completely precipitated, thus giving an automatic indication of the degree of precipitation.

As a matter of fact, however, this constant-voltage method is not used in most of the standard separations, which are rather to be classed as constant-current separations, even though the current may not be absolutely constant. In such a constant-current method something which does not change the results, but not the second metal, must be deposited, together with the first metal. It is evident that if hydrogen is developed it does not change the results. Therefore, if the decomposition voltage for hydrogen in the solution is below the decomposition voltage of one of the two metals, then a constant-current separation becomes possible. In electro-analytic work in former years no voltmeter was generally used in the circuit, and this is the reason why all except some of the most recent separations are constant-current separations.

To apply these principles, Dr. Bancroft has collected the data of former experimenters, and has put them together in tabulated form. Dr. Bancroft gives tables in which the metals and hydrogen are arranged according to the value of their deposition voltage from various solutions. This order is different for different solutions. Tables are given for the sulphates, nitrates and chlorides; cyanides; oxalates; phosphates and tartrates. A second set of tables gives a summary of the majority of the separations for silver, mercury, copper, bismuth, tin, lead, nickel, iron, cadmium and zinc. Dr. Bancroft's rule of classification of the different methods is that if hydrogen is evolved before the second metal, the constant-current method is feasible and is used in practice, otherwise constant voltage must be used. The tables given in Dr. Bancroft's paper show that this rule is generally correct, although there are two or three exceptions, explanations of which are suggested by the author. In general it may be said that the overwhelming majority of the usual electro-analytical separations can be run at constant current without reference to the voltage.

The paper was discussed by Messrs. Bigelow, Carhart, Hering, Keith and Reed. Attention was called to the essential differences between the separation of metals for analytical purposes and the separation of metals in industrial electrometallurgy. In the latter case soluble anodes are often used, which are, of course, not suitable for analytic work. Concerning the



PHOTOGRAPH TAKEN DURING FRIDAY'S SESSION.

electrolytic deposition of brass, Dr. Bancroft expressed his doubts whether brass is really deposited. It seems that when copper and zinc are deposited simultaneously the deposit may look like brass, but the separate particles of zinc and copper can be distinguished by the microscope.

EXPERIMENTAL STUDY OF SOME ELECTRODE EFFECTS.

A paper on this subject by DR. H. T. BARNES, of McGill University, Montreal, Canada, was read, in the absence of the author, by Dr. Bancroft. The author remarked that platinum electrodes under apparently the same conditions do not behave alike. There is generally found a potential difference between two platinum electrodes in a solution. He shows that this is due to the presence of air, which is dissolved in the solution. This is even more important than any air dissolved in the electrodes. When the solution is freed from air, the anomalies disappear. The paper was not discussed.

THE ELECTROLYSIS OF WATER.

A paper on this subject was presented by DR. J. W. RICHARDS, of Lehigh University, and MR. W. S. LANDIS. The authors gave an account of a long series of experiments, in which they investigated the various problems connected with the electrolysis of water from various points of view. A most interesting experiment was made with a closed vessel, consisting of a very strong thermometer tube. It was completely filled with dilute sulphuric acid, care being taken to get rid of dissolved gases by means of boiling. Platinum wires were introduced through the ends, so that the distance between their ends was about 1 mm. The ends of the tube were most carefully sealed with Canada balsam. Under these conditions the authors found that no current would pass, even with an applied e. m. f. of 3.3 volts. As soon as the seal at one end was broken so that air had access, current was found to pass at once. In this experiment the tube was strong enough to stand a pressure of about 5,000 atmospheres, while the evolution of gas by electrolytic action would produce a pressure of 1,800 atmospheres only.

J. W. RICHARDS.

Another set of experiments was made, in order to test Thomson's rule in an interesting manner. The Joulean heat developed during electrolysis was determined from the rise of temperature by means of a thermometer; at the same time the e. m. f. and current were carefully measured. From the difference thus experimentally established between the heat developed and the electrical energy consumed, it was found that the decomposition voltage of water is 1.49, in accordance with Thomson's rule.

The authors arrived at the same result in an entirely different method by observing the cathode under the microscope, while the applied e. m. f. was gradually changed in steps of 0.05 volt. At 1.40, 1.45 volts no gas bubbles could be observed, while they appeared at once at 1.5 volts or above.

The authors have also made an extended study of the residuary current, or, as the Germans call it, Reststrom. Their results confirm the opinion already expressed by Helmholtz, that the gases dissolved in the electrolyte play a very important part in this phenomenon. They found that current passes with any applied e. m. f. below the proper decomposition voltage, the amount of current increasing with the voltage. The concentration of the sulphuric acid used makes very little difference, but the amount of the current depends largely upon the quantity of the gases dissolved in the electrolyte. These gases act somewhat like depolarizers. The authors further made experiments with the electrodes 8¾ meters apart, and in another case a small fraction of a millimeter apart. In the first case there was absolute conformity with Ohm's law, as in metallic conduction, but not in the latter case. The authors also give some notes on the work of Danneel and Bigelow on the same subject.

There was an animated discussion, in which Messrs. Bancroft, Bigelow, Burgess, Cowles, Hering, MacNutt and Reed participated. Mr. Hering doubted the suitability of platinum as electrode material for such experiments, because it combines with hydrogen and oxygen. From experiments made by him, he preferred gold electrodes. Mr. Reed called attention to an experiment made long ago by Faraday, who drew from it the conclusion that if the applied e. m. f. is above a certain value there is electrochemical action, while below this value there is metallic conduction. Professor Burgess described an experiment made by him on the influence of the pressure upon the e. m. f. He used a strong cylinder of steel, filled with a dilute acid solution, and could pass a current with an e. m. f. of less than 1 volt. The current decreased rapidly, but rose again to its former value on shaking the cylinder. Dr. Bancroft made some critical remarks on the statements of the authors on the validity of Ohm's law, and expressed his belief that the experiments could not be considered accurate enough to prove the absolute exactness of Thomson's rule in this case. We have absolute evidence that this rule is, in general, not exact.

EXPERIMENTS WITH METALLIC DIAPHRAGMS.

DR. W. D. BANCROFT pointed out in a paper on this subject that when we interpose a metallic plate between anode and cathode there may pass no current through it, or all the current may pass through it, or any part of the current. Instances of the case when all the current passes through the diaphragm are the mercury in the Castner soda process, and the copper electrodes in the Hayden system of copper refining in the Baltimore works. Instances of metallic diaphragms through which no current passes are the iron-gauze diaphragms in the Castner sodium process and the diaphragms in the Siemens & Halske process for hydrogen and oxygen.

When the diaphragm fills the cross section of the cell completely, all the current must pass through it, if there is any current at all. If the diaphragm is a completely reversible electrode (*i. e.*, if the cathodic electrochemical reaction on one side of the diaphragm is the exact reverse of the anodic reaction on the other side), no extra e. m. f. is required to pass the current through it. If it is not reversible, or only partially reversible, an extra e. m. f. is required to pass the current through, and this e. m. f. is equal to the value of polarization.

If the diaphragm does not fill the cross section completely, no current will flow through it, unless this requires a smaller expenditure of energy than to make the current flow through the electrolyte. Since the resistance of a metal plate is practically always less than the resistance of an equal thickness of electrolyte, current will always pass through an interposed plate, unless prevented by polarization.

If a thick carbon plate is interposed between anode and cathode in a copper sulphate solution, so as to fill partially the cross section, then, when the fall of potential between the ends of the carbon plate, as measured on copper wires dipped in the electrolyte, is less than 1 volt, there is no precipitation of copper. When the fall of potential exceeds 1.4 volts, there is a rapid precipitation of copper on the end of the carbon plate nearest the copper anode.

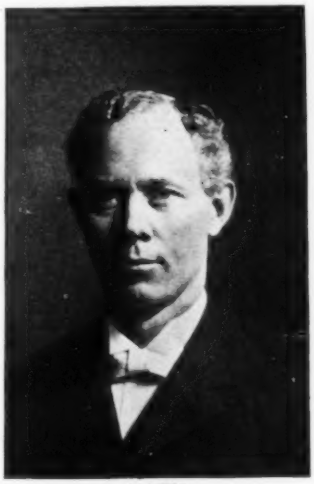
Dr. Bancroft then wanted to make the same experiments with platinum, instead of carbon, and, as a platinum plate of great thickness would have been extremely expensive, he

thought the following arrangement would be equivalent: He placed two movable platinum electrodes in the electrolyte, and connected them outside by a platinum wire. But he found that this was not equivalent to a massive platinum bar. Instead of one electrode being anode and the other cathode, each electrode behaved to a certain extent both as anode and as cathode. The author explains this by means of diagrams, and points to a depolarization phenomenon which here occurs, with the consequent precipitation of copper under differences of potential far below the normal decomposition voltage for the solution. He calls attention to the importance of determining the exact conditions under which decomposition takes place with the minimum voltage, in order to avoid those conditions, for instance, in the electrolytic generation of hydrogen and oxygen when using an iron-gauze diaphragm. The paper was not discussed.

THURSDAY AFTERNOON SESSION.

THE PROTECTIVE ACTION OF ZINC CHLORIDE ON METALLIC IRON.

The first paper of the afternoon session was read by MR. C. J. REED. The rusting or oxidation of metallic iron in the presence of water and saline solutions is now recognized to be an electrochemical process, in which the water or saline solution is the electrolyte, the metallic iron the anode and small particles of impurities in the iron, like graphitic carbon, etc., are the cathode. This combination evidently represents a short-circuited cell, and the iron is attacked. Now, Mr. Reed argues that this attack of iron in a chloride solution would be due to the chlorine ions, and should take place in a zinc chloride solution in the same manner as in a sodium chloride solution. On the other hand, he found that iron nails placed in a zinc chloride solution for two years did not rust in any case. In strong zinc chloride solutions, which had been boiled with metallic zinc and contained no free acid, there was not the slightest action of any kind upon the iron. He asked the adherents of the electrolytic dissociation theory to explain this. The discussion of the paper was very brief.



C. J. REED.

INSULATION MATERIALS, A FIELD FOR CHEMISTS.

The next paper was read by DR. M. VON RECKLINGHAUSEN on this subject. A long abstract of this paper will be found on another page of this issue. The paper was not discussed.

A HISTORICAL REVIEW OF THE STORAGE BATTERY.

A paper on this subject was read by MR. H. B. COHO. It was a concise and probably complete record of the various phases of the development of the storage-battery industry, and of the gradually-extended commercial applications of the storage battery. In view of the fact that the paper was itself a concise *résumé* of an historical development, it is impossible to review it briefly. In the discussion which followed Prof. H. S. Carhart said that in 1881 Planté told him he had tried applying by mechanical means the active material on the lead plates (which was later patented by Faure and Brush), but had found such plates inferior to formed plates. Dr. N. S. Keith stated that, in 1881, he himself had devised a plate which did not require forming.

THE USE OF PYROXYLINE IN ELECTRIC STORAGE BATTERIES.

Another paper on the subject of the electric storage battery was presented by MR. ELMER A. SPERRY. In the first part of the paper the author dealt with the inherent weakness of the positive plate of a storage battery. In practice its life is always found to be shorter than that of the negative plate. The reason is that the particles of the positive plate tend to drop off, on account of expansion and extraction, due to the chemical changes during operation. Moreover, in automobile batteries this tendency of the particles of the positive plate to fall off is increased by the surface wash of the electrolyte. When these particles are allowed to drop off and fall to the bottom of the cell, not only the capacity of the plate is diminished, but there is also the danger of a short-circuit between the positive and negative plates. For all these reasons, it has been found advantageous to cover the positive plate with an envelope to hold the active mass firmly in place. Planté has already made experiments in this line.

Mr. Sperry has developed the pyroxyline envelope, which is made of open-mesh cotton cloth, such as "cheese cloth," carefully freed from water and starch, and chemically treated to form a cellulose nitrate, called "pyroxyline." The addition of a small amount of nitrobenzol in the final washing makes it inert. When dry it is highly inflammable, but not when wet; this was demonstrated by experiments. (The method of winding this pyroxyline envelope around the positive plate was described and illustrated in ELECTROCHEMICAL INDUSTRY, Vol. I, page 149, December, 1902.)

Some questions raised by Mr. C. J. Reed in the discussion elicited the answer by Mr. Sperry that the initial difficulties which were experienced in the manufacture of this envelope have now been entirely overcome, and that batteries with such envelopes have been in continued use for about three years. The pyroxyline envelope cannot be used for the negative plate

THE CONCENTRATION CHANGES IN THE ELECTROLYSIS OF BRINE.

A paper on this subject was read by DR. W. H. WALKER, who took issue with some theoretical opinions expressed by Mr. C. P. Townsend in ELECTROCHEMICAL INDUSTRY, December, 1902, Vol. I, page 119, concerning the increase of the undecomposed sodium chloride concentration in the caustic soda department of a cell for the electrolysis of sodium chloride. Dr. Walker showed how this increase of concentration may be easily explained by the theory of migration of ions, if Hittorf's transport numbers are properly taken into account. At the beginning of the electrolysis only the sodium ions and chlorine ions travel. Afterwards, when sodium hydroxide has been formed, the HO participates in the transmission of the current, so that now both hydroxyl and chlorine ions travel in the direction from the cathode to the anode. This fact complicates somewhat the mathematical theory of the phenomenon, which, however, has been worked out by the author and found to agree with the experimental facts. A diagram was exhibited by the author which illustrated the migration of the ions very clearly, and in another diagram the results of tests were given in curves.

In the discussion Mr. C. P. Townsend and Mr. P. Fireman participated. It was pointed out that the cell to which Mr. Townsend referred in his former article was of special construction, different from that assumed in Dr. Walker's paper. Mr. Townsend stated, however, that, on account of the patent situation, he is not at liberty at present to discuss the whole matter freely, but will do so in future.

THERMO-ELECTRIC FORCE WITHOUT DIFFERENCE OF TEMPERATURE.

DR. HENRY S. CARHART then presented an interesting theoretical paper on this subject, a rather full abstract of which is given on another page of this issue. It was discussed by Messrs. Cowles and Richards. The question was raised as to why the law that in a closed circuit of metals the sum of all the thermo-e. m. f's at the junctions is zero should not also be valid if there are electrolytes in the circuit. Dr. Carhart replied that there is no reason whatever for such a supposition, because the

two cases are fundamentally different. In the case of a closed circuit of metals the assumption that the sum of the thermo-e. m. f's would not be zero would lead to a contradiction with the well-established laws of thermo-dynamics. This is not the case when there are electrolytes in the circuit.

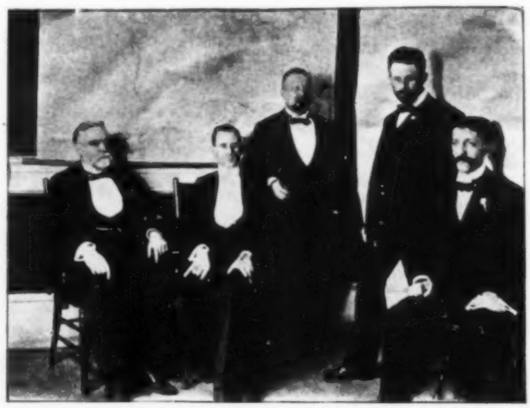
CORROSION OF METALS BY ELECTROLYSIS.

The last paper of the afternoon session was presented by MR. A. A. KNUDSON, who gave a summary of a long series of observations and tests made in connection with electrolytic corrosion. After some introductory remarks on the influence of earth currents on telephone and telegraph lines, he discussed the copper plating of iron ships. Should such construction of vessels come to be used, the principal point is to keep the plating intact, free from punctures or abrasions, the hull closely examined when in dry dock, and exposed places upon the iron replated with a plant which may be carried on board or kept at the dock. The worst thing to do when repairs become necessary would be to put iron patches over the copper-plated hull, as in this case corrosion is bound to follow. A still more important case of sea-water corrosion, due to placing together dissimilar metals, is sometimes found on the propeller shafts of steamers. After a careful consideration of the subject, he concludes it would be the proper thing, when seeking improvements, to abandon the method of attaching brass or bronze

W. D. Bancroft. C. A. Doremus. H. S. Carhart. C. Hering. P. G. Salom. J. W. Richards. C. M. Hall.

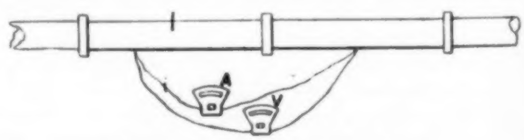
bearings to steel shafts. Concerning the corrosion of bridges, he points out the importance of occasional examinations. If there should be danger, a simple remedy to prevent excessive corrosion would be to keep the iron work well painted, caulk the seams between the iron and wooden planks with oakum and pitch or paint the seams over. The author then discussed at length the electrolytic corrosion of gas and water pipes, and in general the underground metallic structures by the return currents of trolley systems. He gave a summary of numerous tests made in this respect in New York and Brooklyn, especially in connection with the Kent avenue power house. In these tests the way of the return currents was carefully traced. The author concludes that "the *future* possibilities of damage by electrolysis, due to railway currents upon valuable underground structures, as well as those shown to be going on at the present time, should cause grave concern if the electrical conditions as they at present exist are to be continued." The only complete solution of the difficulty would be the adoption of insulated returns by the traction companies, either in form of the conduit system or the double-trolley overhead system.

The paper was discussed at length, notably by Mr. Carl Hering, who pointed out that the measurement of potential differences, as in common use in connection with the problem of the stray currents from the rails used as return, is essentially wrong. What is of importance for the electrolytic corrosion of gas and water pipes is the current which flows in them and passes from them at a special point into the earth. Measurements of e. m. f. do not indicate accurately the current which flows, because the resistance is also a very important factor which determines the current. To find the current which flows in a pipe, Mr. Hering suggests the following method, illustrated in the adjoining diagram: Connect two points of the pipe with a voltmeter V and take the reading e_1, which, according to Ohm's law, is RI, if R is the resistance of the pipe between the two points and I the current in the pipe. Then connect the same two points of the pipe also to an ammeter A and take the readings e_2 of the voltmeter and i of the ammeter. In this case the current i flows through the ammeter circuit, so that the current in the pipe is only $I - i$; hence Ohm's law gives $e_2 = R(I - i)$. From this and the first equation, $e_1 = RI$, it follows at once that the current I in the pipe is $I = \frac{i\ e_1}{e_1 - e_2}$. This is therefore a simple method for determining the current in the pipe by means of an ammeter and a voltmeter. At such points of a pipe where currents tend to leave, and thus cause corrosion, Mr. Hering suggests to connect the pipe metallically with a plate or block of zinc. Then there will be a tendency to "suck" the current into the earth, not from the iron pipe, but from the zinc plate, so that the corrosion of the iron pipe is prevented, although the zinc is gradually eaten up.



W. McMurtrie. C. F. Scott. A Franke. M. von Recklinghausen. A. von Isakovics.

Mr. Knudson replied to the remarks of Mr. Hering concerning the use of a voltmeter that the latter was only assumed by him to show existing potential differences, and that the conclusions which he drew concerning the current in the pipe were checked by other methods. Messrs. Breneman, Keith, Reed and Richards also participated in the discussion. The question was raised whether it would be advisable to cover gas and water pipes with cement, in order to prevent electrolytic corrosion, but the cost of this remedy was thought to be too high. The



MEASURING THE CURRENT IN A PIPE.

use of zinc, as suggested by Mr. Hering, to protect pipes is now in large use in boilers and condenser tubes on steamers to prevent corrosion, and has been found very satisfactory. It may also pay to prevent the corrosion of steel docks by connecting them with a plate or block of zinc, which will, of course, be gradually destroyed. Aluminium should, theoretically, be better than zinc, but has not proved so satisfactory in practice, probably on account of the oxide film which is always formed on an aluminium surface.

FRIDAY MORNING SESSION.

A NOTE ON THE COMPOSITION OF ELECTROPLATING SOLUTIONS.

DR. N. S. KEITH presented a paper on this subject, which is abstracted at length on another page of this issue. There was quite a long discussion of this paper. Mr. H. E. Heath discussed the use of unipolar machines as designed by him for electroplating or electrolytical processes. The pulsating current from a commutating machine requires a certain constitution of the solution, while this is not the case with the absolutely constant current obtained from a storage battery or from a unipolar machine. Mr. C. O. Mailloux then spoke at length in a very interesting manner on experiments made by him years ago, together with Dr. Keith. He also discussed a process developed by him by a laboratory study for electrotyping. For this purpose he studied carefully the specific resistance of various solutions, and developed a method in which, by the use of a current density of 500 ampères per square foot, he could reduce the time of the process from six hours to forty-five minutes. He also sketched the mental inertia of the average electrotyper, who prefers to retain a bad process instead of taking the troubles connected with the introduction of a more perfect process. Messrs. Eddy, Hering, Johnson and Reed also participated in the discussion.

WALTER NERNST.

MODERN ELECTROLYTIC COPPER REFINING.

A paper on this subject, by MR. TITUS ULKE, was then read, in the absence of the author, by Dr. Richards. A full abstract of this paper will be found elsewhere in this issue.

DETERMINATION OF VAPOR DENSITIES IN THE ELECTRIC FURNACE.

A highly interesting paper was then presented by the distinguished guest of the Society, PROF. WALTER NERNST, of Goettingen, Germany, on a method of determining the density of vapors at temperatures of 2,000° to 2,200° C. The principle of the method is the old one of Victor Meyer, which could, however, not be used up to the present for higher temperatures than about 1,800° C., because no suitable vessels were available. Dr. Nernst had tried to use mixtures of rare earths, but was so far unsuccessful in this direction, although he thinks that these trials are not hopeless. The firm of Heraeus then succeeded in making vessels of iridium. They are very expensive, and, being brittle when cold, may easily be injured. But they have proven very satisfactory for the present purpose. On account of the high price of iridium, the apparatus must be made in very small dimensions, and this necessity set up new problems which were ingeniously solved by Dr. Nernst.

The furnace is a tube of iridium. It is heated from about 2,000 to 2,200° C. by a current of 300 or 400 amp. at 2 to 3 volts. For determining the temperature, the laws of radiation from an "absolutely black body" are used. Below the iridium furnace an electrolytic incandescent filament was provided, which has been tested by photometric methods for different currents. The light radiated from the inside of the tube is reflected by means of a small mirror into a telescope. The current passing through the electrolytic filament is then adjusted until it no longer shows dark against the background of the furnace, nor yet shows bright. The light emission from the furnace is thus determined, and the laws of radiation of a black body are applied.

The vapor-density apparatus consists of a thin tube, 15 cm long, 0.5 cm internal diameter, terminating in a bulb 5 cm long, 1 cm diameter, all of iridium, in one piece. The thin end has a brass tube attached at right angles, to which a rubber tube makes attachment to a small glass tube, in which the motion of a mercury meniscus allows readings to be made of the volume of vapor expelled from the tube. Small egg-shaped vessels of iridium are used to contain the substance, and the determination must be made on a very small scale.

Some results obtained with this method were given by Dr. Nernst, the substances so far investigated being water, mercury, sodium chloride and potassium chloride.. The surprising accuracy of the method and the great experimental skill of Dr. Nernst were highly commended in the discussion by Messrs. Baekeland, Bancroft and Richards.

NOTES ON ELECTRIC ENDOSMOSE.

A paper on this subject was presented by DR. W. D. BANCROFT. He pointed out that whenever we have diaphragms we have the phenomenon of electrical endosmose, and this phenomenon should not be neglected, as is often done in textbooks, which only consider the concentration changes due to the migration of the ions. Dr. Bancroft gave some results of experiments showing that electric endosmose may amount to much more than is generally supposed. The matter is of great importance for technical processes, which require a greater or smaller value of this effect. It is important that to a certain degree it is possible, by proper choice of the diaphragm, to obtain the degree of endosmosis wanted for a special purpose. The question of the possibility of negative endosmose was also discussed.

IONS AND ELECTRONS.

In a paper with this title DR. L. A. PARSONS gave a summary of the researches which have led to the modern electronic hypothesis. A rather full abstract of this paper is given elsewhere in this issue. The paper was not discussed.

UNIFORMITY OF ELECTROCHEMICAL EQUIVALENTS.

In a paper on this subject MR. CARL HERING pointed out that, as long as absolute accuracy is impossible, the establishment of some uniform values for units and constants is far preferable to continued uncertainty and to the use of different constants for the same thing by different persons or in different countries. In electrochemistry there exists at present a very annoying lack of uniformity in the very constants used in most calculations, namely, in the electrochemical equivalents. While accuracy seems hopeless at present, it is best to enjoy the next best thing, which is uniformity, which is well within reach. Mr. Hering proposes to adopt the table of atomic weights of the American Chemical Society. This, together with the legal electrochemical equivalent for silver, namely, 0.001118 gram per coulomb, as adopted by the International Electrical Congress of 1893, gives a complete set of electrochemical equivalents. (The complete and very full table, published by Mr. Hering in the January issue of ELECTROCHEMICAL INDUSTRY, is based on these values.) The charge of a univalent gram ion (for $O = 16$) becomes 96,538.5 coulombs, which, cut down to four significant figures, which is all, if not more, than the basic figures warrant, becomes 96,540 coulombs. The

electrochemical equivalent of hydrogen on this basis is 0.010441 milligram per coulomb.

In the discussion which followed Messrs. Bancroft and Richards doubted the advisability of adopting a uniform set of values. Dr. Bancroft remarked that careful researches of T. W. Richards have shown that the legal value of the electrochemical equivalent of silver is incorrect, the error being about 0.04 per cent. Mr. Hering replied that, for any practical purpose, this difference would be of absolutely no account.

The Electromotive Force of Alloys.

A brief note on this subject was presented by Dr. W. D. Bancroft, on the e. m. f. of an alloy against one of its metals. He pointed out that experimental measurements sometimes lead to an apparent anomaly, which, however, is explained by the fact that in such cases there is no chemical equilibrium. The paper was not discussed.

The Electrolytic Production of Metallic Compounds.

An elaborate paper on this subject by Prof. C. F. Burgess and Mr. C. Hambuechen was then read by Professor Burgess. A long abstract of the same will be found elsewhere in this issue. There was no discussion of this paper.

FRIDAY EVENING SESSION.

On Friday evening a joint meeting of the American Institute of Electrical Engineers and of the American Electrochemical Society was held, in the College of the City of New York. President Scott, of the Institute, made the opening remarks. The name of the Electrochemical Society indicates the intimate connection between two branches of science and of industry. The fundamental mysteries of electricity and of chemical affinity are not far apart. He contrasted the rapid development of engineering at the present time with the slow progress in former years. This difference is due to a change of the methods of scientific observation and of scientific generalization on the one hand and in the facility of the inventor and engineer to develop new processes. On the one hand, we marvel at the advance which has been made in science, invention and engineering; on the other hand, we find that in every direction we have only entered upon new fields of nature which lie before us promising and unexplored.

APPARATUS USED IN MR. HAMMER'S EXPERIMENTAL LECTURE.

Experimental Lecture of Mr. Hammer.

Then followed a very elaborate experimental lecture by Mr. William J. Hammer, on radium and other radio-active substances, with a consideration of phosphorescent and fluorescent substances, the properties and applications of selenium and the treatment of disease by ultra-violet light. In this paper Mr. Hammer has collected an enormous amount of information, and, in view of this fact, it seems impossible to attempt to give a brief abstract of it. The paper will be printed in full in the Transactions of both the American Institute of Electrical Engineers and the American Electrochemical Society. The author exemplified certain fundamental principles connected with the phenomena upon which he treated, and in considering these subjects, all of which may be said to be on the border land of science, he brought out, by means of experiments,

lantern slides and illustrations, the practical and commercial side. Some interesting notes were given on the observation made by Heydweiller, who had found that a sample of radium lost in weight one whole milligram in fifty days. On the other hand, J. J. Thomson states that if a square centimeter of surface were covered with pure radium, it would only lose in weight one thousandth of a milligram in a million years. In view of the great discrepancy in these statements, Mr. Hammer corresponded concerning this point with J. J. Thomson, Besquerel, Lord Kelvin, Crookes, Curie and Heydweiller, and the views of these different authors are given in the paper. It appears that Heydweiller's statement, given above, must be looked on as very uncertain. This investigator is continuing his researches. We intend to comment on some special points of Mr. Hammer's paper in our next issue.

SATURDAY MEETING.

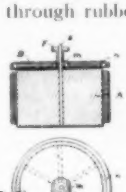
THE ELECTRODEPOSITION OF METALS UPON A ROTATING CATHODE.

A paper on this subject, by MR. J. G. ZIMMERMAN, was read, in the absence of the author, by Professor Burgess. A rather full abstract of this paper is given on another page of this issue.

The paper was discussed at length by Messrs. Bancroft, Burgess, Eddy, Heath, Hering and Taggart. Mr. Hering expressed his opinion that stirring of the electrolyte would be as good as revolving the cathode, and would be a simpler mechanical arrangement. The principal point is that you always have at the cathode a surface layer of electrolyte containing a sufficient amount of the ions which you want to deposit. Mr. Taggart referred to some recent experiments of Dr. Edgar F. Smith, who, by rotating the anode, considerably reduces the time required for electro-analytical work.

ELECTROLYTIC CONDUCTION WITHOUT ELECTRODES.

MR. A. B. MARVIN reported the results of a series of experiments made to determine quantitatively if it is actually possible to pass a current through an electrolyte without the use of electrodes of any sort, either for introducing the current or for detecting its flow. He first tried to construct a unipolar dynamo, which seemed promising on account of the absence of a commutator, and because the moving conductors can be made short and thick, and hence of low resistance. The dynamo was constructed as shown in the adjoining diagram. The armature consisted of a wooden block B, in which radial channels had been chiseled out, filled with electrolyte. This armature was adapted to sit on the shaft S, and to be revolved by means of the pulley F. Two annular channels M, N were provided to serve as slip rings, from which the current could be led off from the moving part through rubber tubes to a suitable measuring instrument.



To prevent the solution from flying out, because of centrifugal action, the channels and rings were tightly filled with wicking, connection being made with the external circuit by wet cloth brushes bearing on the wicking in the channels. The external circuit consisted of a solenoid of glass tubing filled with the electrolyte, the solenoid serving as the coil of galvanometer. It was found, when the armature was set in motion, that only a very slow speed could be maintained, because of the tendency of the solution to fly out. The experiment was therefore unsuccessful.

In another experiment the principle of the induction motor was applied. It was tried to induce, by means of a rotating field, eddy currents in an electrolyte in a jar which, by reaction, would then tend to revolve with the field. The experiment was not very successful, but at least a tendency to rotate was observed. If it should be possible to obtain rotation in this way, the number of revolutions would depend upon the specific resistance of the electrolyte used, and although a method of determining specific resistances in this way does not appear altogether convenient, the author thinks that in certain special cases it might be of value.

The best results were obtained with a combination of two transformers. The primary of the first was excited from an alternating current power circuit. Its secondary winding, which consisted of a tube of electrolyte, served also as the primary of the second transformer, and the secondary of this second transformer was connected to a telephone receiver. Thus the impulses induced in the core of the first transformer were transmitted through the electrolyte to the core of the second, and thence to the telephone. The trouble with this arrangement was the existence of a magnetic leakage or stray field, which caused the telephone to hum even when there was no electrolyte in the tube representing the secondary of the first transformer and the primary of the second. When the electrolyte was then poured into the tube, the humming in the telephone changed to a loud noise.

The paper was discussed at length by Messrs. Bancroft, Burgess, Carhart, Hering, Hopkins, Reed and Richards. Professor Bancroft referred to some former experiments of Boys, and Professor Hopkins described an apparatus which he had used for the same purpose. There was also some controversy concerning the depositions of metallic conduction and electrolytic conduction.

POTENTIALS OF ZINC IN AQUEOUS SOLUTIONS.

A very elaborate paper, by DR. H. E. PATTEN and MR. W. R. MOTT, was then read by Mr. Mott. The first part of the paper deals with single potentials of zinc in various aqueous solutions, the principal results being as follows: The measurements of single potentials of zinc in mixtures show that the predominating influence rests with that acid radicle which by itself gives the highest single potential. This is as would be expected from the analogy presented by alloys where the metal of the alloy highest in the electrochemical series controls the single potential. A striking exception was found in mixtures of $KMnO_4$ and K_2CrO_4, where the single potential of zinc was much lower than in either alone. One field of great importance where the principle applies with great force is for any solution containing iron salts. In all mixtures in the conduction all salts present participate, although the voltage may be less than the decomposition point of some of the salts. In the case of mixtures, the lowest decomposition point corresponds to that salt giving the lowest decomposition point alone, the highest to that salt giving the highest alone. The single potential of zinc in various solutions of acids, bases and alkali salts varies greatly, the limit being from + 1.00 volt and — 1.00 volt. There is, however, a general centralization of values about + 0.52 volt, and the percentage of the total number of determinations between + 0.42 and + 0.62 volt is little over 50 per cent. Oxidizing reagents, as would be expected, tend to give low values. The so-called solution tension of zinc seems to be a "rather elastic quantity." The authors then discuss other influences which must be considered in this connection.

The second part of the paper deals with decomposition points. The authors first discuss the various methods used for this purpose. The first is Le Blanc's method, in which a galvanometer in series with the cell is used to note the point where continuous current begins to flow. This method is rather unsatisfactory, on account of the residual currents, which are never lacking. Other methods are the observation of the voltage when products first appear, discharge potential methods and the method of extending the CR line to the ordinate axis.

The authors then give data on the curves given in their paper, mainly on solutions of sulphates. Large residual currents were noted in H_2O_2, and in all solutions containing iron, of which there were several. The polarization voltage for H_2O_2 equals zero, and mixtures of ferrous with ferric salts tend to let very large currents pass with very low voltages.

The general principle may be laid down that in electrolyzing the highest current efficiency is realized by avoiding the simultaneous presence in solution of one metal in two or more stages of oxidation.

The CR line of the upper branches of the curves is practically parallel to the CR line of the lower branches, showing that all the salts in a solution share in the conduction equally above and below their decomposition points. The highest decomposition point corresponds to the decomposition point of $ZnSO_4$ in nearly all of the mixtures containing $ZnSO_4$.

NOTES ON THE ELECTRODEPOSITION OF NICKEL.

A paper by MR. WOOLSEY MCA. JOHNSON was then presented on this subject. A long abstract of the same will be found elsewhere in this issue.

A LABORATORY ELECTRIC FURNACE.

The final paper of the meeting was read by MR. B. MCNUTT, who described an inexpensive laboratory furnace of the Siemens type. The electrodes are a carbon rod and a graphite crucible. The latter is formed by a cylindrical bundle of arc-light carbon, bored out at the top so as to form a cup in which the graphite crucible is placed. The connection of this crucible with the stranded conductor is made by opening the latter and binding the strands in with the carbons.

There were read by title the following papers: "The Influence of Some Impurities in Salt upon the Yield of Soda by the Amalgam Process," by DR. J. W. WALKER; "The Formation of Nitric Acid under Electric Influences," by DR. C. W. VOLNEY; "Free Ions in Electrolytic Solutions," by DR. W. R. WHITNEY. These papers will be printed in the Transactions of the Society.

EXHIBIT OF ELECTROCHEMICAL APPARATUS.

MR. A. EIMER, of the firm of Eimer & Amend, then exhibited and explained some improved electrochemical apparatus. Several new types of electric furnaces were shown, among them the forms noticed in ELECTROCHEMICAL INDUSTRY, November, 1902, page 112, and April, 1903, page 267. A very interesting new carbon-determining apparatus was also exhibited. It has been designed by Mr. Geo. O. Seward, chemist of the Willson Aluminum Co., and will be described in our next issue.

The presidential address was delivered by DR. J. W. RICHARDS on Saturday evening. A full abstract of the same will be found elsewhere in this issue.

In the following we give an alphabetical list of all the members and guests who registered at the meeting:

C. E. Acker, Niagara Falls, N. Y.; Mrs. C. E. Acker, Niagara Falls, N. Y.; G. P. Adamson, Easton, Pa.; Geoffrey C. Adams, New York, N. Y.; Robert S. Allyn, New York, N. Y.; G. T. Archer, New York, N. Y.; S. W. Ashe, Brooklyn, N. Y.; Baxter M. Aslakson, Oak City, Pa.; Sherman I. Austen, Mount Vernon, N. Y.; J. W. Aylesworth, East Orange, N. J.; Mrs. J. W. Aylesworth, East Orange, N. J.; Leo Baekeland, Yonkers, N. Y.; H. E. Baer, New York, N. Y.; Mrs. D. W. Baker, Jr., Newark, N. J.; E. B. Baltley, Perth Amboy, N. J.; K. B. Bancroft, Ithaca, N. Y.; Wilder D. Bancroft, Ithaca, N. Y.; Chas. Batchelor, New York, N. Y.; Miss Beal, Niagara Falls, N. Y.; F. M. Becket, Niagara Falls, N. Y.; G. F. Bendly, Niagara Falls, N. Y.; S. D. Benoliel, Niagara Falls, N. Y.; A. G. Betts, Troy, N. Y.; S. Lawrence Bigelow, Ann Arbor, Mich.; L. J. Binswanger, New York, N. Y.; C. H. Bissell, Douglaston, N. Y.; Henry S. Blackmore, Mount Vernon, N. Y.; W. S. Block, New York, N. Y.; C. J. Bogue, New York, N. Y.; Malcolm Bonsell, Morristown, N. J.; R. Boudeville, Paris, France; Chas. S. Bradley, New York, N. Y.; C. Brasseur, New York, N. Y.; W. S. Brayton, New York, N. Y.; A. E. Breneman, New York, N. Y.; J. Stanford Brown, Reading, Pa.; W. H. Browne, Jr., New York, N. Y.; John Bry, Brooklyn, N. Y.; C. F. Burgess, Madison, Wis.; O. Bussmann, Berlin, Germany; Walter Scott Cameron, New York, N. Y.; Miss E. Cameron, New York, N. Y.; Henry S. Carhart, Ann Arbor, Mich.; Miss M. J. Carum, New York, N. Y.; C. F. Chandler, New York, N. Y.; Carl D. Chasteney, Trenton, N. J.; Virgil Coblentz, New York, N. Y.; H. B. Coho, New York, N. Y.; Edw. A. Colby, Newark, N. J.; Alfred H. Cowles, Cleveland, Ohio; F. B. Crocker, New York, N. Y.; Mrs. Chas. H. Cromwell, Savannah, Ga.; T. E. Crossman, New York, N. Y.; A. F. Cushman, New York, N. Y.; C. A. Doremus, New York, N. Y.; Mrs. C. A. Doremus, New York, N. Y.; F. E. Drake St. Louis, Mo.; W. Dreyfus, New York, N. Y.; G. Drobegg, Brooklyn, N. Y.; Mrs. G. Drobegg, Brooklyn, N. Y.; Ed. F. Duffy, Yonkers, N. Y.; Joseph A. Dyhnée, Brooklyn, N. Y.; A. H. Eddy, Windsor, Conn.; August Eimer, New York, N. Y.; Wm. M. Eisen, New York, N. Y.; Mrs. Wm. M. Eisen, New York, N. Y.; F. M. Ekert, Mt. Vernon N. Y.; A. H. Eyles, Philadelphia, Pa.; P. Fireman; C. W. Fletcher, New York, N. Y.; R. A. Fliess, East Orange, N. J.; Hans Foersterling, Perth Amboy, N. J.; F. Forbes, New York, N. Y.; E. A. Fourneau, New York, N. Y.; C. E. Freeman, Chicago, Ill.; A. B. Frenzel, Denver, Colo.; S. E. Getty, Yonkers, N. Y.; F. A. Godley, New York, N. Y.; G. McM. Godley, New York, N. Y.; W. E. Goldsborough, Lafayette, Ind.; F. Gottsch, New York, N. Y.; Albert C. Hale, Brooklyn, N. Y.; Mrs. A. C. Hale, Brooklyn, N. Y.; F. E. Hale, New York, N. Y.; W. B. Hale, Chicago, Ill.; Chas. M. Hall, Niagara Falls, N. Y.; A. P. Hallock, New York, N. Y.; D. Hand, Newark, N. J.; Edwin Harrington, Yonkers, N. Y.; Edw. Hart, Easton, Pa.; J. C. Hatzel, New York, N. Y.; H. O. Havemeyer, Jr., New York, N. Y.; H. E. Heath, Windsor, Conn.; M. Heike, New York, N. Y.; Carl Hering, Philadelphia, Pa.; Edwin F. Hicks, New York, N. Y.; B. H. Hite, Morgantown, W. Va.; N. M. Hopkins, Washington, D. C.; R. L. Hopkins, Passaic, N. J.; George M. Howard, Philadelphia, Pa.; Henry Howard, Brookline, Mass.; E. J. Hutchinson, Cincinnati, Ohio; Mrs. E. J. Hutchinson, Cincinnati, Ohio; M. R. Hutchinson, New York, N. Y.; R. W. Hutchinson, Jr., Brooklyn, N. Y.; Alois von Isakovics, New York, N. Y.; Mrs. A. von Isakovics, New York, N. Y.; H. A. Jackson, New York, N. Y.; W. McA. Johnson, Hartford, Conn.; Franklin H. Kalbfleisch, Babylon, L. I.; Alfonse Kaufman, New York, N. Y.; N. S. Keith, New York, N. Y.; Mrs. Keith, New York, N. Y.; J. J. Kennedy, New York, N. Y.; Wm. Houston Kenyon, New York, N. Y.; Edw'd F. Kern, Troy, N. Y.; C. V. Kerr, New York, N. Y.; E. C. Klipstein, New York, N. Y.; A. A. Knudson, New York, N. Y.; Wm. Kuchrow, Brooklyn, N. Y.; W. S. Landis, Bethlehem, Pa.; Palmer H. Langdon, New York, N. Y.; Jos. Law, New York, N. Y.; E. J. Lederle, New York, N. Y.; C. E. Lockwood, New York, N. Y.; M. Loeb, New York, N. Y.; E. G. Love, New York, N. Y.; L. R. Loveman, Orange, N. J.; Arthur M. Lumley, New York, N. Y.; L. Lyndon, New York, N. Y.; F. Machalske, New York, N. Y.; Barry MacNutt, Bethlehem, Pa.; I. J. Macomber, Bethlehem, Pa.; C. O. Mailloux, New York, N. Y.; M. E. Maltby, New York, N. Y.; Cloyd Marshall, New York, N. Y.; K. G. Martin, New York, N. Y.; T. C. Martin, New York, N. Y.; A. B. Marvin, Washington, D. C.; H. T. Matthew, New York, N. Y.; F. J. Maywald, Brooklyn, N. Y.; W. A. McCoy, Perth Amboy, N. J.; Douglas C. McMurtrie, New York, N. Y.; Wm. McMurtrie, New York, N. Y.; Ralph McNeill, New York, N. Y.; H. A. Metz, New York, N. Y.; Dwight D. Miller, New York, N. Y.; J. H. Miller, New York, N. Y.; P. S. Miller, New York, N. Y., Jos. S. Mills, New York, N. Y.; I. F. Moltkehansen, Perth Amboy, N. J.; A. Monell, New York, N. Y.; G. M. Monnan, Camden, N. J.; Mrs. E. E. Montell, Baltimore, Md.; Miss E. C. Montell, Baltimore, Md.; J. T. Morehead, New York, N. Y.; W. R. Mott, Madison, Wis.; C. W. Moulton, Poughkeepsie, N. Y.; E. H. Mullin, New York, N. Y.; J. B. Nau, New York, N. Y.; J. G. Needham, New York, N. Y.; W. Nernst, Goettingen, Germany; G. M. S. Neustadt, New York, N. Y.; Chas. Nordhaus, Jr., Hoboken, N. J.; R. J. Nunn, Savannah, Ga.; T. J. Parker, New York, N. Y.; George W. Patterson, Jr., Ann Arbor, Mich.; Frank A. Pattison, New York, N. Y.; Albert B. Pacini, New York, N. Y.; Louis A. Parsons, Baltimore, Md.; L. Peaise, New York, N. Y.; F. B. Peirson, Brooklyn, N. Y.; W. M. Petty, Rutherford, N. J.; Henry Noel Potter, New York, N. Y.; H. F. Raess, New York, N. Y.; H. D. Randall, New York, N. Y.; M. von Recklinghausen, New York, N. Y.; Chas. J. Reed, Philadelphia, Pa.; H. Reisnegger, Augsburg, Germany; J. W. Richards, Bethlehem, Pa.; C. Richardson, New York, N. Y.; E. E. Ries, New York, N. Y.; Mrs. E. E. Ries, New York, N. Y.; I. L. Roberts, New York, N. Y.; E. F. Roeber, Philadelphia, Pa.; Mrs. E. F. Roeber, Philadelphia, Pa.; A. J. Rossi, New York, N. Y.; Mrs. A. J. Rossi, New York, N. Y.; Samuel S. Sadtler, Philadelphia, Pa.; P. G. Salom, Philadelphia, Pa.; E. S. Sargent, New York, N. Y.; G. Saunders, Rutherford, N. J.; Carl Schlegel, New York, N. Y.; B. E. Schlesinger, Boston, Mass.; Emil Schmidt, New York, N. Y.; Mrs. Emil Schmidt, New York, N. Y.; F. E. Schmitt, New York, N. Y.; George P. Scholl, Philadelphia, Pa.; Carl R. Schultz, New York, N. Y.; C. Walter Schultz, New York, N. Y.; R. C. Schuepphaus, New York, N. Y.; Walter Schwabe, Rutherford, N. J.; J. A. Secor, Brooklyn, N. Y.; S. Sheldon, Brooklyn, N. Y.; Louis Simpson, Ottawa, Canada; Edmund S. Smith, Niagara Falls, N. Y.; Edw. W. Smith, Philadelphia, Pa.; H. F. Smith, Concord, Mass.; W. L. Smith, Concord, Mass.; Chas. F. Scott, Pittsburg, Pa.; C. C. Speiden, Summit, N. J.; E. A. Sperry, Cleveland, Ohio; A. S. Swan, New York, N. Y.; Jos. Swift, Homesdale, Pa.; Walter T. Taggart, Philadelphia, Pa.; Ed. R. Taylor, Penn Yan, N. Y.; Mrs. E. R. Taylor, Penn Yan, N. Y.; N. Tesla, New York, N. Y.; Philip S. Tilden, New York, N. Y.; Horace Holden Thayer, Yonkers, N. Y.; J. Thelberg, New York, N. Y.; C. E. Thiess, Hoboken, N. J.; P. H. Thomas, New York, N. Y.; O. M. Thowles, Newark, N. J.; Maximilian Toch, New York, N. Y.; F. J. Tone, Niagara Falls, N. Y.; C. P. Townsend, Washington, D. C.; S. G. Updyke, Minneapolis, Minn.; Walter L. Upson, Princeton, N. J.; B. Viola, Brooklyn, N. Y.; C. W. Volney, Keyport, N. J.; Mrs. Volney, Keyport, N. J.; C. D. Vreeland, Upper Montclair, N. J.; L. G. Waite, New York, N. Y.; Leonard Waldo, New York, N. Y.; W. H. Walker, Boston, Mass.; E. P. Walters, New York, N. Y.; D. W. Ward, New York, N. Y.; C. D. Warner, Newark, N. J.; W. D. Weaver, New York, N. Y.; Mrs. F. G. Weichmann, New York, N. Y.; W. S. Weichmann, New York, N. Y.; J. E. Weidemann, New York, N. Y.; G. A. Wells, New York, N. Y.; Benj. R. Western, New York, N. Y.; Gus. Westman, New York, N. Y.;

Edward Weston, Waverly Park, N. J.; Joseph Wetzler, New York, N. Y.; C. E. Whitney, New York, N. Y.; C. E. Whitney, Mt. Vernon, N. Y.; Jos. Whitney, Homesdale, Pa.; F. J. Wiechmann, New York, N. Y.; Wm. S. Wiedon, Schenectady, N. Y.; Henry Wigglesworth, New York, N. Y.; Harvey Wiley, Washington, D. C.; B. T. Witside, Yonkers, N. Y.; Alfred Wohlauer, Berlin, Germany; W. A. Wood, New York, N. Y.; Frank M. Zeller, Philadelphia, Pa.

NOTES ON THE ELECTRODEPOSITION OF NICKEL.

In the following we give an abstract of an interesting paper read by MR. WOOLSEY MCA. JOHNSON at the New York meeting of the American Electrochemical Society. His paper is supplementary and explanatory of his article published in the February issue of ELECTROCHEMICAL INDUSTRY (page 212):

The use of hot solution (above 40° C.) has been much praised in the technical press, and, in fact, has been given, in the author's opinion, undue prominence. In the first place, the statement that it is impossible to deposit thick coherent coatings at a low temperature is untrue. Perhaps the best piece of electrolytic nickel which the author has ever seen was a chance deposit on the wire suspending a plater's basket. The solution was cold, but the fortuitous use of a low-current density and the great care taken to keep a clear solution caused this remarkable deposit, which was as hard as steel, perfectly reguline and possessed a dull-silver finish. In the second place, a hot solution would be used in any electrolytic nickel-refining process, not for the reason that thick platings can only be made from a hot solution, but because the voltage can best be reduced by heating the solution as high as possible without causing undue evaporation and consequent creeping of nickel salts. The cost of power in an electrolytic-nickel process would be a very large percentage of the total cost, as from five to ten times as much power would be used in refining nickel as in refining copper. This is because of the self-evident fact that nickel must be deposited from an alkaline or neutral or very slightly acid electrolyte, because of its high electropositive character; while copper can be deposited from a strongly acid solution, because it is 0.567 volt lower in the electrolytic series. Again, if any working-current density were used, say 15 to 30 ampères per square foot, to cut down the interest charge on metal tied up in the vats, the electrolyte would warm up by the C^2R loss in the vats. In fact, if a cold electrolyte were desirable, which it is not, for the commercial reasons above stated, it would be necessary to place refrigerating pipes in the storage vats to keep the temperature of the electrolyte below 40° C.

There is an advantage in the use of hot solution, namely, to be allowed the use of a high current density and to facilitate circulation. The advantage of hot solutions in making tough deposits has been known to practical electroplaters in this country for some fifteen years. There are several secret "dopes" which can be used to make a smooth homogeneous deposit. The author has experimented with 15 or 20 of these, and it is really surprising to note the benefit that arises from the addition of a very, very small amount, say, one part in a thousand. The excellence of the Balbach nickel cathodes was partly due to the use of a hot solution, which, of course, was unavoidable, but more to the use of an efficient secret "dope" which was discovered by Mr. William Thum.

The use of a hot electrolyte, which is unavoidable for the commercial and practical reasons above stated, is bad, in that it accelerates the reaction velocity of the basic iron, cobalt and nickel salts in the electrolyte. This means that the electrolyte becomes turbid, and a turbid electrolyte always means warty, poor deposits.

The author then discusses the reasons why the use of a hot electrolyte prevents the curling up of nickel deposited at high current density. This is, to his mind, directly connected with the formation of nickel-hydrogen alloys.

It has long been known that many metals are capable of occluding hydrogen, and that this absorption profoundly modifies their magnetic, physical and electrochemical properties. In electrolytically depositing nickel, nickel hydride is always formed, as is shown by the decreased current efficiency, even when no hydrogen is visibly evolved. It is also proven by the fact that nickel electrolysis is not a reversible process, like copper refining.

Electrolytic nickel, or, to be exact, nickel hydride, is deposited under a considerable electrochemical stress. The molecules of the nickel hydride are in a state of abnormal strain—something similar to the strain of the molecules in tempered steel. This can be proved physically by the following evidence: Nickel was electrodeposited on a malleable nickel cathode sheet, 18 x 12 inches, which fitted in a groove in the end vat, which was 12¼ inches wide. The groove was made of slats, ½ x ½ inch in cross section, nailed to the vat. The surface exposed was about 18 x 11⅛ inches. At the end of six days' deposit out of a hot solution, the electrolytic sheet, still adhering to the soft sheet, was wedged in so strongly that two men were required to pull it out. The whole sheet was now elastic. In addition to the potential energy of electrolytic solution, as measured by the potentiometer, there was also the potential energy of an elastic body under strain.

Now this elasticity and "overvoltage" (which is really electrolytic elasticity) both gradually decrease with time or with increase of temperature. Electrolytic nickel, which is as hard as steel and brittle, becomes as soft as lead on annealing. This overvoltage decreases with time and heat also. Both these properties seem to be dependent on the amount of hydrogen co-deposited.

Take a piece of stiff paper and wet one side of it; allow it to stand, and it will be observed that it curls up. Allow it to stand still longer, and it will slowly unroll. What has happened? The surface wetted becomes soft as annealed electrolytic nickel becomes soft. The other side is elastic, as electrolytic nickel is elastic. Unequal strains are set up, and the sheet curls up. When the annealing action of the water soaking through the sheet makes the whole sheet limp, these strains are equalized and the sheet uncurls.

Precisely the same thing happens in the electrodeposition of nickel. This "curling up" of electrolytic nickel is caused by the fact that there is an unequal strain between the inside and outside layer. The inside layer, when deposited, had the same abnormal strain, but with time this tension has become more normal by a slow annealing action of the nickel hydride. The outside layer has had, however, no time for the molecules to adjust themselves, and consequently the tension is greater on the outside than on the inside. The curling is always such that the outside layer (or last deposited) is on the concave side of the bending.

It has been observed that nickel will curl when the temperature of the electrolyte is 60° C. if the current density is too high, or if the deposit is made on a heavily oiled or graphitized surface. This layer could not have been uniform, and consequently there were parts of a surface where nickel was thin, causing lines of weakness where the nickel cracked and curled off. The higher the current density, or, better still, the "electrovoltage," to use the scientific term, the greater the strain. Nickel will often stick to a clean surface when it will curl up in a few hours from the same surface when oiled. Nickel will stick to a matte or rough surface when it will curl up from the same surface smooth. If the proper "dope" be added to the solution, nickel has a remarkable hardness and toughness. Mr. Thum took one of his cathodes, ⅛ inch thick, placed it against a strong wood frame, and fired at this point blank with a Winchester rifle. The bullet was stopped by the nickel cathode and drew out a long cone, at the end of which was found what was left of the bullet—nothing. This is shown in the adjoining sketch of Mr. Thum. The left-hand diagram shows the section of this long cone. The diagram in the center is the section of a test piece penetrated by a higher-velocity projectile being drawn out somewhat longer before giving away under the strain. Samples of soft boiler steel, tested at the same time, were both penetrated, but showed

ragged edges, somewhat like the right-hand diagram. The experiment simply showed that, at least to tensile strength and ductibility, the nickel was superior to the steel plate.

If the electrolyte be made gas-free by allowing to drip through a vacuum and be kept in a substantially gas-free condition, it will be found that the tendency to curl up of nickel deposited from this electrolyte is diminished. A large part of the hydrogen which is ordinarily occluded by the nickel is dissolved by the electrolyte, because the electrolyte has its hydrogen pressure reduced to a low limit. As a consequence hydrogen is always passing from a state of the nickel hydride to the state of hydrogen dissolved in the electrolyte. By this means it is possible to make heavy platings of nickel, provided the circulation of the gas-free electrolyte keeps pace with the

EXPERIMENTS OF MR. THUM ON THE MECHANICAL RESISTANCE OF NICKEL CATHODES AND OF STEEL.

formation of hydrogen at the nickel cathode. This process and apparatus for it have been patented by the author. The tenacity and reguline character of nickel deposited from a gas-free electrolyte is greatly benefited by this, and for certain purposes, such as the manufacture of "starting sheets," this device would be of value. For general refining purposes it has, in the author's opinion, small worth.

Mr. Johnson showed several pieces of electrolytic nickel, 4 x 6 inches, deposited under different conditions. Two of these were badly "curled up" by the use of excessive current density in a hot solution. A third specimen, deposited at a lower "electrode voltage," was smooth, but somewhat brittle. A fourth one was of remarkable physical properties, tough, malleable and smooth. This had been deposited from an electrolyte kept gas-free by use of the vacuum.

CONDITIONS OF PROGRESS IN ELECTROCHEMISTRY.

DR. J. W. RICHARDS' splendid presidential address, delivered at the recent New York meeting of the American Electrochemical Society, is a lucid and highly interesting analysis of the conditions which make progress in electrochemistry possible. It is one of the finest presidential addresses delivered before technical societies in recent years, and it is with great regret that, owing to the limitation of space, we can give in the following only an abstract of this address, while for the full address the reader must be referred to the Transactions of the Society.

"To live is to progress, and to progress is to live. A science which does not progress, petrifies. As the progress of electrochemistry is, however, only one phase of scientific progress in its more general sense, a clear understanding of the laws governing the latter will teach us as their corollaries the conditions for progress in the former. Science advances in many different ways, along many different paths and by many different agencies." For the purpose of his discussion the author classifies this subject under six headings, as follows:

I. DISCOVERY OF NEW FACTS IN ELECTROCHEMICAL SCIENCE.

"I place this as the corner-stone of progress in our science. Given a freshly-flowing current of new electrochemical facts, and all the other elements of progress have a chance to exist. No less certain than this is the location of the birthplace and the identity of the sponsers of these newly-born facts. The birthplaces are chemical, electrical and physical laboratories; the sponsors are the investigators, the searchers after truth—the professors, students, employees, private investigators and all who, with the insatiable thirst for more knowledge, are pushing back the thick curtain of the unknown, which hems us in so closely on every side. The elect among these workers, the highly-favored few, are the professors of electrochemistry provided with well-equipped electrochemical laboratories. They are in the position to do or to direct the most valuable investigations, and are also under the moral obligation to publish freely to the world all that they discover. The giants of the electrochemical fraternity are in this class: Davy, Faraday, Bunsen, Arrhenius, van't Hoff, Ostwald, Nernst, Moissan. The labors of such workers, given to the world in their publications, form the *body* of electrochemical science, and their thoughts—its *soul*. Such are the heroes of science; men who work for the work's sake, who sacrifice time, money and often health to increase the boundaries of our knowledge, and then keep nothing back. These are the sort of men whose grateful memory we should perpetuate in bronze and marble, as well as in our literature. Great wealth has been amassed by the application of the facts discovered by these pioneers, and yet the facts are at the command of anyone who will read our literature. And there are others of the rank and file following cheerfully the same paths; our journals and transactions teem with the results of new researches, by which the humble worker in one corner of the scientific field gains the knowledge gleaned by many workers, and in return he contributes what he can, and every such contributor, mark it well, receives in return a hundred-fold for all that he himself contributes."

The author refers to the fact that the German-speaking countries count up alone at their universities and technical schools 15 chairs of electrochemistry and 12 electrochemical laboratories, which have been the source of the greater part of the advance of electrochemical science in the last ten years. He asks: "Are we not out of comparison with Germany in that respect?" and urges that America should soon begin to establish chairs of electrochemistry and build well-equipped laboratories to go with them. Then our boast, that America is "the electrochemical center of the world," might begin to be more than the empty boast of a successful money maker; then we may begin to be an *illuminating* center, radiating knowledge to the rest of the world.

In place of professors and professional laboratories, however, America is blessed with another class of investigators, who are no less industrious in acquiring facts, and to whom a large part of our commercial success is directly ascribable; that is the small army of patient investigators in the laboratories of our industrial plants, who are searching over ground not yet explored and accumulating facts of value in their special industrial lines. They are, however, generally not at liberty to publish what they discover, but Dr. Richards urges that, *when the research has achieved its financial purpose, the scientific results should be given to the world.* In other words, when the laboratory experiments have led up to the technical process, and the latter has been protected by patents, then the scientific principles discovered during the investigation should be freely published.

II. CLEARER KNOWLEDGE OF THE LAWS CORRELATING THESE FACTS.

"By means of facts, correlating, discussing and deducing therefrom, we arrive at a knowledge of the laws of the science, the rules governing its various phenomena and according to which its manifestations invariably proceed. Such deductions are the goal of pure science; they contain no element of speculation, hypothesis or theory, and represent man's deepest insight into the phenomena of nature." The author refers to the work of Faraday, Ohm and Joule, and warns us not to think that there remains very little more in the nature of generalizations to be discovered. We could not make a greater mistake. If facts are discovered, the recognition of unforeseen generalizations and the establishing of new laws is bound to follow.

Such discoveries are usually the privileges of the experimenter, as he gets the facts at first hand. "The electrochemist not blessed with laboratory facilities has, however, free entrance to this field. He may be only a student, a looker-on

at what others are doing, a reader of the newly discovered and recorded facts, but if he is at the same time a thinker, a compiler, an analyst, with the power of collating, dissecting and deducing, he may, in the seclusion of his study, discover laws which escape the observation of others less studious, and thus render a service of the highest value to the science."

III. MORE RATIONAL THEORIES OF THE WHY AND WHEREFORE.

"As soon as facts accumulate and laws are discerned, the scientist inevitably begins to reflect on the why and wherefore. He commences to search for relations, to imagine connections and dependencies and to make pictures of the mechanism of the phenomena." The author refers to Dalton, Arrhenius and Nernst, and continues: "Thus there are theories and theories, some poor, some good and some almost perfect in their applicability, since, *granting their premises*, they give an explanation satisfactory to the mind of all observed phenomena. Such theories are not only allowable, but necessary. We must have them much as an artisan must have a working drawing of the machine he will construct. The drawing is but paper and ink, which never moves or works, but it guides the workman in putting his ideas into realities. So theories help us to handle mental conceptions as if they were concrete things, and thus to imagine and discover relations and generalizations which would otherwise be beyond our mental grasp."

"The danger of the development of a science comes when a theory, by being believed too implicitly, and by not being open to constant revision, becomes a straight-jacket for the growing science. Like a 'creed outworn,' it stifles criticism, warps the judgment, engenders blindness and bias in its adherents and undue hostility and acrimony in its opposers. We should be slow in revising our theories, or in discrediting a theory which has done us good service in its day, just as we are conservative in correcting our 'confessions of faith' or indulgent and sympathetic with the weaknesses of a faithful old servant. But, after all, when a theory has come to be considered so firmly fixed as to be above criticism, or so certainly true as to be above the possibility of revision, or so well established as to thunder its excommunications on those who dare to think or believe otherwise, such a theory had better be placed at once in the museum of scientific petrifications, where it properly belongs and where it can do no further harm."

"If science is progressing, theories must progress, too. They will be outgrown; much light will give way to more light; imperfect pictures of phenomena, founded on crude assumptions, must be replaced by better pictures, corresponding more accurately to the newer and the larger truth, and then progress begins anew. All theories have been of some use in their day. They have helped men to grasp concretely evanescent, immaterial phenomena; they have very often been splendid guides to further experiment and new discoveries; they have at times been so helpful that many have mistakenly thought them infallible, and, lastly, they have been stepping stones to better theories. One great hindrance of scientific progress is the common human weakness of becoming partisans of a theory."

"The biased investigator, with a theory to support, is apt to support it at all hazards. He catches at every straw which helps to establish his preconceived idea of what he should find, and is virtually blind to facts which disprove his ideas; while his report of his work, flickering through his perverted imagination, gives as often as not an entirely distorted picture of the facts."

"The pitfall is particularly dangerous to the young and ardent investigator. Believing almost implicitly in the rectitude and ability of his instructor, he takes to his professor's hobby with enthusiasm, and spurs it on to feats which make more careful scientists shudder."

"To make a specific application of these remarks, who has not felt that the most effective blows dealt the present theory of electrolytic dissociation have come from the excessive zeal of its warmest adherents? Out of their camp has proceeded half-fledged treatises on the theory, such as inaugural dissertations of would-be doctors of philosophy or text-books compiled by *privat-docents*, in which the theory was simply done to death and made a laughing stock. Have we not met writers or lecturers on this theory who shunned a fair debate on their written or spoken statements, because, forsooth, they were themselves conscious that they had surpassed the safe bounds of reasonableness in those statements? Such an attitude and such results are the consequence of holding a theory too tenaciously, and not 'subject to revision.' There are scientific zealots as well as religious bigots, and the one does as much harm to the progress of true science as the other does to the development of pure religion."

(*To be continued.*)

THERMO-ELECTROMOTIVE FORCE WITHOUT DIFFERENCE OF TEMPERATURE.

We have repeatedly referred in these columns to the important and very interesting recent thermo-dynamical investigations of PROF. HENRY S. CARHART, Ann Arbor, Mich., on concentration cells, and on galvanic cells in general. His results were given in two papers read before the American Electrochemical Society, at the Philadelphia and Niagara Falls meetings (ELECTROCHEMICAL INDUSTRY, Vol. I, pp. 2, 58), and in two papers published by Dr. Carhart in the September and January issues of ELECTROCHEMICAL INDUSTRY (pages 9 and 178). In his investigations relating to the *rôle* of thermo-electromotive forces in a voltaic cell, he has applied them to the analysis of the temperature coefficient; to the localization of the absorption and generation of heat at the electrodes; to the variation of the electromotive force with the concentration of the electrolytes, and to the electromotive force of a concentration cell. Dr. Carhart's view of the temperature coefficient as the difference of the electrolytic thermo-electromotive forces per degree at the two electrodes, is sustained by the measurements in a most satisfactory manner. Dr. Carhart has also shown mathematically the difference in heating at the electrodes when a current flows to be an extension of the Gibbs-Helmholtz principle, and has confirmed the results by quantitative experiments.

In the discussion following his Niagara Falls paper before the American Electrochemical Society, and in a recent German technical journal, the objection had been made to these applications, particularly as regards the concentration cell, that such thermo-electromotive forces come into play only when the junctions are at different temperatures. It is to this objection that Dr. Carhart replies in a paper read at the New York meeting of the American Electrochemical Society, an abstract of which follows:

The inquiry is naturally divided into two parts: First, the existence of thermo-electromotive forces without difference of temperature at the junctions, and, second, the resultant thermo-electromotive forces in a closed circuit.

The Peltier phenomenon is itself sufficient evidence that it is not necessary to heat a junction in order to excite there an electromotive force. In fact, this phenomenon is but a single example of a very general law, namely, that when a current flows across any part of a conducting circuit, which is the seat of an electromotive force, energy is either given to the current or is taken from it, according as the electromotive force at the point is directed with the current or against it. Thus, in a direct-current motor the current does work against the counter-electromotive force generated by the motor, and the product of the motor is mechanical motion. In a "booster," on the other hand, the generated electromotive force has the same direction as the current, and the current receives energy from the generator. Similar relations exist in a storage battery. Now, unless the devices employed are such that the work done by the current at the seat of an opposing electromotive force takes some other form of energy, the circuit is invariably heated. In the opposite case the conductor gives us heat energy and cools. In a Daniell cell, for example, the thermo-electro-

motive force at either electrode is directed from the electrolyte to the metal. At the zinc, therefore, heat is generated, while at the copper it is absorbed, and the flow of current produces a difference of temperature between the electrolytes surrounding the electrodes. These temperature changes have nothing to do with the resistance of the cell, and they are proportional to the first power of the current.

The direction of the thermo-electromotive force at a copper-iron junction at moderate temperatures is from copper to iron. In accordance, then, with the general law, when a current is sent across this junction from iron to copper heat is generated and the junction is heated. If the current passes from copper to iron, heat is absorbed and the junction is cooled. The Peltier effect proves the presence of an electromotive force at the contact of dissimilar substances, and the value of this electromotive force is determined by the usual thermo-electric experiments. This statement is justified by the measurements made on the Daniell cell before alluded to. The following are the results: The temperature difference between electrodes observed in a Daniell cell was 0.0165, while the temperature difference calculated from thermo-electromotive forces was 0.0160.

Helmholtz remarks, in his celebrated memoir on the "Thermo-dynamik Chemischer Vorgäenge," as follows: "There are, besides, differences of heating at the two electrodes, which, in their manner of appearance, are similar to Peltier's phenomena in the case of thermo-electric currents, even though they are perhaps of different origin." Helmholtz said "perhaps" because experimental evidence was lacking at that time, but the agreement now established by Dr. Carhart between theory and observation justifies the statement that they are the same in origin.

Reference is made to a very striking illustration of the general law under discussion. It has been brought out by Duddell, in London, within the past year. He finds an electromotive force between carbon and carbon vapor, and it is directed from the latter to the former. When, therefore, the arc is formed heat is generated at the positive carbon, where the current flows against this thermal electromotive force, and is absorbed at the negative carbon, where it flows in the same direction as the electromotive force there. This is an interesting explanation of the higher temperature of the positive carbon.

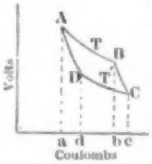
It is not open to question, then, that there exists an electromotive force at the junction of two dissimilar substances. The other question remains to be answered. We have been taught that the thermo-electromotive force integrated around a circuit, composed of two or more metals, vanishes when the whole circuit is at one temperature. This law is undoubtedly true for circuits wholly metallic. The denial of it would involve the absurdity of self-acting thermo-electric engine, continually converting the heat energy of the surorundings into the energy of an electric current, *without any change in the circuit which would limit the process.* It would be a kind of perpetual motion, by which the kinetic energy of diffused heat might be converted into potential energy, or be made more available. The integrated electromotive force around such a circuit, therefore, vanishes, unless there are differences of temperature.

When the surface is partly metallic and partly electrolytic, the case is quite different. Imagine a zinc rod bent in the form of a U, and let the two ends be immersed in a solution of zinc sulphate. If, now, one side of such a cell be slightly warmed, the warmer end of the rod becomes the positive electrode of a thermo-electric cell. But the flow of current produces changes in the concentrations at the electrodes, with a resulting back electromotive force. If the equalization of concentrations by diffusion is prevented, the electromotive force becomes zero by the decrease of the thermo-electromotive force at the electrode and its increase at the negative.

If two zinc rods joined by a zinc wire are immersed in solutions of zinc sulphate of different concentrations, the combination is a concentration cell. The current through the cell is from the more dilute to the less dilute solution, and the flow of current acts to equalize the concentrations and reduce the electromotive forces. Hence the device as a thermal engine is self-limiting. It can convert some of the equally-diffused heat of its surroundings into electric energy, but it cannot do so continually, and can repeat the process only by having the cycle of operations reversed.

Dr. Carhart then gives a very lucid explanation of the problem by applying to it a complete Carnot's cycle. The cell may be contained in a case impervious to heat except through the bottom, and the porous partition separating the two solutions may be a good conductor of heat, but preventing sensible admixture of the liquids. All parts of the cell may then remain at the same temperature. The usual cycle of the well-known four operations of Carnot's cycle may now be carried out.

The first operation is to place the cell on a heat-conducting stand of the temperature T, and let a small current flow till its electromotive force has fallen from the value denoted by the ordinate *Aa* in the figure to that denoted by *Bb*. The temperature remains at the value *T* by absorption of heat from the heat-conducting stand. The change in concentrations causes the decrease of electromotive force, and the cell works along the isotherm *AB*. Heat is absorbed because the thermo-electromotive force working with the current at the positive electrode is greater than the opposing thermo-electromotive force worked against at the negative. During this operation the work done by the cell is equal to the area *ABba*. The co-ordinates are electromotive force (volts) and quantity of electricity (coulombs).



The second step consists in transferring the cell to a stand which does not conduct heat and passing the current till the electromotive force falls to the value *Cc* and the temperature to *T'*. The cell then works along the adiabatic *BC*. Its temperature falls because the heat absorbed at the positive electrode is greater than the heat generated at the negative electrode. The internal resistance of the cell and the current are both supposed to be so small that the heat generated within the cell, proportional to the square of the current, is infinitely small compared with quantities proportional to the first power of the current. In this second operation the electromotive force falls for two reasons—the change in the concentrations and the fall of temperature. The curve *BC* is therefore steeper than the curve *AB*. The work done by the cell during this second stage is represented by *BCcb*.

For the third step of the process the cell is transferred to a heat-conducting stand at the temperature *T'*, and a reverse or charging current is passed through it at the lower temperature and electromotive force till the work done on the cell (not on its external circuit) along the lower isotherm *CD* equals the area *CDdc*. This work must be considered as negative. The cell gives out heat to the stand, the reverse current augments the difference of concentration and the electromotive force rises.

In the fourth step the cell is transferred to the first heat-conducting stand again, and a charging current is passed till the temperature of the cell rises to T. The opposing thermo-electromotive force is now greater than the direct, and heat is generated into the cell. Work done on the cell along this adiabatic *DA* is equal to the area *DAad*.

The cell is completely reversible, and has been brought back to initial conditions in all respects. It has at the end of the process the same internal energy, whether chemical or thermal, as at the start, while the excess of work done by the cell during the entire cycle over the work done on the cell is donated by the area *ABCD*. This energy is derived from the heat taken in during the first operation, with the usual ratio for the efficiency of a reversible process. The cell works like any other

thermo-dynamic engine, which is carried through a complete cycle of operations, taking in H units of heat at the higher temperature T, and giving out H^1 units at the lower temperature T^1.

A concentration cell carried through such a cycle may convert heat into electrical energy indefinitely. So may a steam engine and an electric generator. If the cell does not work in a cycle, its function is then limited to the first operation along the isotherm AB. Gas, under pressure in a tank, may do the same thing. An essential element is the presence of stress. In the concentration cell this stress is the difference of the thermo-electromotive forces at the two electrodes. There is no question that there is such a difference, and it is not neutralized by a thermo-electromotive force between the two solutions.

A temperature coefficient is the difference of the thermo-electromotive forces per degree between the metal and the electrolyte at the two electrodes. Whenever a cell has a positive temperature coefficient, it absorbs heat and converts it into electric energy. A concentration cell has an electromotive force proportional to its absolute temperature. It also converts heat from its surroundings into electric energy. It does it by means of the fact that the thermo-electromotive force at the positive electrode is greater than that at the negative. Its electromotive force is therefore thermo-electric. If any part of its electromotive force is derived from internal energy, such as the heat of solution, the argument is in no way invalidated. To the extent that it takes in heat from its surroundings and converts it into electric energy, its electromotive force is purely thermo-electric.

It is obvious that any reversible voltaic cell, having a positive temperature coefficient, may be carried through such a cycle, and the area $ABCD$ will represent the work done by the internal energy of the cell. The electric pressure, by means of which this heat energy is transformed, is denoted by the second term of the Helmholtz equation, expressing the thremo-electromotive force of a voltaic cell. This term is the integrated value of the thermo-electromotive forces in the circuit. Any voltaic cell with a positive temperature coefficient converts absorbed heat into electric energy. A concentration cell is an extreme type, which absorbs all, or nearly all, of its electrical output as heat.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

BY CARL HERING.

INDUSTRIAL ELECTROCHEMISTRY.

Treating Nickeliferous Copper Mattes.—In the Transactions of the Am. Electrochem. Soc., Vol. I, page 95, Ulke describes a process for treating such mattes. Guenther has now devised a somewhat similar one in Borchers' laboratory, although different in important points, as appears from the description given by VON KUEGELGEN in the *Zeit. f. Elektrochemie* of March 19th. Guenther, like Ulke, uses the copper-nickel alloy as the anode in an acid electrolyte for the production of copper at the cathode. The solution thus obtained during the process is treated chemically to separate the last traces of copper and iron from the nickel. The nickel is finally extracted electrolytically. But while Ulke uses for this an ammoniacal nickel solution with insoluble (lead) anodes, Guenther uses an acid solution and soluble anodes. Guenther's alloy contained 26.43 per cent. Cu, 50.18 per cent. Ni, 21.23 per cent. Fe and some sulphur and carbon. This was cast into anodes. Between two anodes a copper sheet was placed as cathode. The electrolyte consisted of an acid copper sulphate solution of 17.5° Baume, and contained 38.4 gr Cu and 62.7 gr free acid per liter. The current density was 200 ampères per square meter. The voltage in the beginning was 0.56, but soon increased to 1.16, at which value it remained. The ampere-hour efficiency was between 95 and 97 per cent. When the solution became poor in copper, and contained only about 0.5 per cent., the copper deposit began to become spongy; but, with lower current densities, good copper could even then be obtained. Concerning this step of the process, he sums up his results by saying that a copper-nickel-iron alloy of the composition mentioned can be used as anode in regular, continuous operation, and electrolytic copper of the best quality is thereby obtained. It is, however, necessary not to allow the copper contents in the bath to decrease considerably below 1 per cent. if it is desired to use the high current density (200 ampères per square meter), which is preferable for several reasons. The last traces of the copper must be removed from the solution by chemical means. The copper contents of the alloy is not sufficient to furnish all the copper deposited at the cathode, hence the difference must be added to the bath at continuous intervals, in form of a solution which is rich in copper, but may contain iron and nickel. Such a solution is easily obtainable in this process. In order to avoid an increase of sulphuric acid, this added solution should contain a correspondingly smaller amount of acid. The second step of the process is the separation of the last traces of copper from the solution, and the separation of iron and nickel by chemical means. Guenther thinks that these traces can be most easily removed by means of precipitation by hydrogen sulphide. For the separation of the iron from nickel, he recommends separating the nickel in the form of nickel ammonium sulphate, which crystallizes out when the solution is cooled, while the iron remains in solution. If the iron and nickel are present in a proportion of one to fifteen, this separation is nearly quantitative. If this proportion is one to two, about 90 per cent. of the nickel is separated. The third step of the process is the electrolytic treatment of the nickel salt for the production of metallic nickel. Guenther first tried insoluble (lead) anodes and various electrolytes, but he found two disadvantages, one being the low solubility of nickel ammonium sulphate and the other the relatively high voltage required. He thinks the latter is due to the fact that at the anode lead peroxide is formed, together with lead sulphate. The former, which is a good conductor and firmly adherent at the anode, will include the particles of lead sulphate, which is a poor conductor, and in this way a layer of high specific resistance is formed. This formation is prevented by using soluble anodes. Moreover, it is desirable to use for the electrolyte a nickel salt which is more soluble than nickel ammonium sulphate, and has a smaller tendency to crystallizing out with a decreasing temperature. The nickel ammonium sulphate obtained in the former steps of the process is therefore transformed into $NiSO_4$. For commercial reasons, it is necessary to recover the ammonia. The principle of his process is to utilize the anodic energy of the current by making the electrolyte at the anode a mixture of two salts, one of which will electrochemically attack the metallic anode, while the other decomposes the soluble metallic compound thus formed nearly at the moment at which it is formed, the result being the regeneration of the solvent and the formation of an insoluble salt, such as is useful for pigments. This idea led to the necessity of a diaphragm separating the cathodic part of the cell containing the nickel

sulphate from the anodic part containing the mixture above mentioned. Experiments were made with lead, copper and zinc anodes. In the case of lead, he used in the anodic electrolyte mixture sodium chlorate as the salt dissolving the anode, and sodium sulphate, sodium bichlorate or sodium carbonate as the salt for precipitating the pigment. He similarly tried various mixtures in the anodic part of the cell with copper and zinc anodes, and in all cases he obtained good nickel at a moderate voltage and satisfactory ampère-hour efficiency; but in every case the anodic by-product was, for some reason, unsatisfactory. He therefore concluded that his original idea was not practical and had to be modified, and he now uses in the anodic part of the cell only the salt which dissolves the anode; but the precipitation of the insoluble salt is made outside of the cell. With lead anodes, he uses sodium chlorate in the anodic part of the cell, as before, for dissolving the anode; then lead chlorate is formed at the anode, and at the same time at the porous diaphragm on the surface looking towards the anode, and lead sulphate is obtained in the form of a thick layer. The lead chlorate thus obtained was changed outside of the cell into chromate, the electrolyte being thereby regenerated. The sulphate is changed into $PbCrO_4$, according to the equation $PbSO_4 + Na_2CrO_4 = PbCrO_4 + Na_2SO_4$, this reaction going on readily at ordinary temperature. The chlorate is very good, and, by varying additions of NaOH, various shades can be easily obtained. In the electrolysis the voltage varied between 3.5 and 4 volts, at a current density of 400 to 500 ampères per square meter and a temperature of 60° to 65° C. The ampère-hour efficiency of the nickel production was above 90 per cent. when no higher current density than 400 ampères per square meter was used. The nickel produced was good.

Aluminium.—That indefatigable compiler, J. B. C. Kershaw, has a second article on the present position of the aluminium industry in the Lond. *Elec. Rev.*, April 10th. He gives some data concerning companies who have introduced aluminium, as a substitute for copper, for overhead electric conductors. The alloys of aluminium appear to have a promising future in motor-car construction work, and the manufacture of such alloys may become a flourishing sub-branch of the aluminium industry. "Builders of automobiles will, however have to recognize that aluminium and its alloys are not absolutely non-corrosive under all weather conditions, and they will be well advised if they cover all exposed surfaces with some protective varnish." The use of aluminium plates as a substitute for zinc, or in place of stone for lithographic work, is extending rapidly. Aluminium continues to be used largely as an addition to molten iron and steel at the moment of casting. The Goldschmidt process for producing high temperatures with powdered aluminium, mixed with iron oxide, appears to be widely used. The use of aluminium is also increasing in the form of the aluminium-magnetism alloy, "magnatism," which has a specific gravity of 2.52, is harder than pure aluminium and more suited for milling and screw-cutting purposes.

An article on the good forging properties of aluminium bronze is given by Sperry in the *Metal Ind.*, April.

Electrometallurgical Production of Iron and Steel.—The *Eng. and Min. Jour.*, April 4th, reprints an illustrated article from the London *Engineer* of March 13th, giving very brief descriptions of the following processes: Conley, Harmet, Keller, Kjellin and Stassano. In general, in all the electric iron-smelting processes the actual reduction of the ore is effected by the coke or other carbonaceous matter with which it is mixed, and an addition of lime or other fluxing compound is also required in order to obtain a slag that will become fluid at the temperature of the furnace; therefore the saving of fuel when using the electric furnace does not amount to much more than "1,050" pounds of coal per ton of iron or steel produced. (This does not agree with the figure below; either must be a misprint in the reprint from which this abstract is taken.) In the ordinary blast furnace, worked under the best conditions, one ton of iron can now be produced with 1,800 pounds of coke, of which 1,400 pounds represents that which is required theoretically for combining with the oxygen of the ferric oxide in the ore. If the average price of coke is $5.25 per ton, the actual saving effected by substituting electricity for coke as heating agent is only $2.50 per ton of iron produced. This sum would therefore have to cover the cost of the electric power, and also of the briquette making, required by most of the electric-furnace processes. From the figures given for the energy consumption in the above-mentioned processes, it is concluded that, even when no special crushing of the ore and mixing with the fluxing, reducing and binding materials is required as a preliminary to the operation of the electric-furnace processes, competition with the ordinary blast-furnace procedure is improbable. "When briquette making is first required, the position of the electric-furnace processes would appear to be hopeless." In countries where fuel is very expensive, water-power abundant and the necessary raw materials are found, these processes may have a limited field of usefulness, but their development, even under these favoring conditions, will be dependent upon the enforcement of high-tariff duties on imported iron and steel and upon a brisk home demand for these metals. In the iron-smelting industry of countries favored with a cheap supply of fuel the blast furnace will still easily hold its own. It will not be until coal and coke have become much more costly than they are to-day that the electric furnaces will displace the blast furnace—a type of furnace which is the most perfect fuel-consuming apparatus in general use, and is estimated to possess a thermal efficiency of over 70 per cent.

Beecker has an illustrated article on the Kjellin electric steel process in use at Gysinge, Sweden, in *L'Ind. Electrochimic* for March.

Metallurgy.—Among the other recent literature on electrometallurgy is a summary in *Glueckauf*, February 28th, by Schnabel, of the progress made in 1902 in various processes, especially in those for obtaining gold, silver, copper, lead, zinc and nickel from their ores. It consists mostly of brief descriptions taken either from articles in other journals or from patent specifications.

Carbon Electrodes.—A summary of notes on processes for the manufacture of carbon electrodes is given in the *Zeit. f. Elektrochemie*, March 26th. Besides an illustrated description of Acheson's well-known method of making graphite electrodes, the following notes on the method of making carbon electrodes in the German plant of Lessing are given. This manufacture has been taken up by those who make arc-lamp carbons, etc., the special feature of the new branch being the necessity of using very large machines. A single one of the hydraulic presses used for this purpose weighs 70,000 kg, and gives a total pressure of 2,000,000 kg, which, even for the largest cross sections used in practice, represents a pressure of 340 kg per square centimeter. The raw material is the retort carbon of gas works. By means of brushes all adherent impurities are carefully removed. For this purpose the original pieces, which often weigh 50 kg, are crushed into small pieces of hand size, and are then heated to 1,200° C. in the absence of air. The material is then pulverized into extremely fine powder and mixed with absolutely dry tar. It is then formed, pressed and left in the air for several days, in order to harden. The next step is to heat them in furnaces to 1,300 degrees. This is the most difficult operation, as the heating must be done slowly, in order to get the whole mass of the carbons to a uniform temperature and remove all the tar in the mass. It is recommended to spend about two weeks for the gradual heating of the carbons to the maximum temperature and for the cooling. The French company, Le Carbone, uses the Girard & Street process of making graphitized electrodes. Their furnace is designed for continuous operation. The carbon prisms pass through it from the top to the bottom, and are heated up to white heat by several

intense arcs. Their normal furnace consumes 10,000 ampères at 130 volts. The principle of the process is that each carbon in the arc zone serves as electrode for one or several arcs.

THEORETICAL AND EXPERIMENTAL.

Potassium from its Molten Hydroxide.—It may be recalled by those who have followed the literature on the electrolysis of molten salts that Lorenz, of Zurich, has offered what seems to be a very plausible explanation or theory of the poor ampère-hour efficiency sometimes obtained, and, what is more interesting from a theoretical standpoint, of the fact that the voltage may then be even lower than the theoretical. His explanation is that the cathodic deposit remains in part suspended in the liquid, forming what he calls a mist, which, when it reaches the anode, acts as a depolarizer and forms the original compound again. Le Blanc and Brode have recently claimed that it was impossible to get metallic potassium from its hydroxide, notwithstanding that it is very simple to get sodium from its hydroxide. LORENZ and CLARK, in this connection, refer, in the *Zeit f. Elektrochemie*, April 2d, to the theory of Lorenz, stating that this phenomenon is analogous to the vaporization phenomenon, and is dependent upon the vaporization of the metals at the temperature of the bath. For the theory of the deposition of metallic sodium or potassium from their molten hydroxides, it is of importance that the vapor tension of potassium is greater than that of sodium at the same temperature; the tendency for the deposited metal to redissolve and form metallic mist is therefore much greater for potassium than for sodium. According to Lorenz's theory, it is necessary for the production of metallic potassium from its molten hydroxide that the cathode is inclosed by a porous diaphragm, which serves to hold the potassium mist together. Experiments have fully confirmed this view. He uses as cathode an iron wire of 3 mm thickness, which passes through the top of a magnesite globe, the bottom of which is open. This globe is placed in the molten salt, and acts as a porous cup. After the electrolysis has been finished the globe is left for some time in the bath, which is cooled down, so that the open bottom of the globe is covered with a layer of solid hydroxide. The globe is then taken from the bath while it is still plastic; it is then placed in kerosene and allowed to cool to ordinary temperature. If the globe is then broken, it is found to be filled with solid potassium. In exactly the same way the authors electrolyzed molten barium hydroxide in order to get barium, but, after electrolysis, barium oxide, and not barium, was found in the globe. The authors assume that the deposited barium reacts at once with the barium hydroxide, perhaps according to the equation $Ba(OH)_2 + Ba = 2BaO + H_2$. Magnesite was found to be an excellent material for diaphragms for the electrolysis of molten hydroxide. It has already been used by Darling for this purpose. It is not suitable for the electrolysis of molten chlorides.

Bipolar Electrodes, or Metallic Diaphragms.—Bancroft, in a recent paper, gave the results of experiments made to study the behavior of a metal plate inserted in an electrolyte between the anode and the cathode, but not connected to either nor filling the whole cross section of the liquid. His paper was read before the American Electrochemical Society, and will be found abstracted elsewhere in this issue. It seems that BROCHET and BARILLET made quite similar researches, which are described by them in the *Zeit. f. Elektrochemie*, March 26th. In all their experiments the authors used copper sulphate as the electrolyte. In their first experiments they used platinum as anode and platinum as intermediary plate. Later they used for the latter a platinum plate coated with copper on the side towards the cathode, and finally they used a copper anode. The observations made in these different cases are described in detail, especially for the conditions under which the intermediary plate acts as a bipolar electrode or as an inert plate. The experimental results seem to be what would be expected from theory. DANNEEL, in an article on the same subject in the same journal, describes quite a number of similar experiments, and also gives some theoretical notes on these experiments of Brochet and Barillet. Among his own experiments is the following, in which he used copper plates as electrodes and copper sulphate as electrolyte. He built up an intermediary diaphragm of arc-lamp carbons, 7 cm long and 1 cm thick. They were piled up, and thus formed a 7 cm thick porous diaphragm, which sets up a very small resistance to the migration of ions, and, although it conducts metallically, it does not give rise to any chemical action at its terminals as long as the difference of potential between these terminals is not above a certain value; it is, at the same time, absolutely durable.

Decomposition Curves of Copper-Salt Solutions—In the same journal, April 2d, ABEL has a note on a recent paper of Miss Heiberg, who deduced decomposition curves of various copper-salt solutions; in which curves the abcissas are the applied e. m. f's and the ordinates the currents. These show two sharp bends, one corresponding to the discharge of cupric ion to metallic copper, the second being 0.1 volt lower, and had been assumed by Heiberg to correspond to the discharge of cuprous ions to metallic copper. The present author suggests that it is more probable that it corresponds to the partial discharge of cupric ions to cuprous ions.

Cathodic Deposition of Lead.—In another note in the same issue ELBS and RIXON point to the fact that in the electrolysis of certain lead salts the lead is deposited on the cathode in two different forms, either as bright, thin crystals or as a sponge consisting of needles, with a dull luster. They then state that they have found that an electrolyte in which the lead at the cathode is deposited in the first form always begins to yield spongy lead from the moment when it contains fourvalent lead ions.

Voltameters with Platinum Electrodes.—BARTORELLI has studied in detail the polarization and resistance of voltametric cells consisting of platinum electrodes dipping into a more or less concentrated solution of sulphuric acid, and describes his researches in the *Phys. Zeit.*, March 15th. He finds that as the current increases the polarization increases also, but not in proportion to it. At high currents a maximum is attained, and this maximum is maintained for all higher values. This result is of importance with regard to the ionic theory. For concentrations of 1, 5, 10 and 15 per cent. the maximum polarizations are attained with current densities of 50, 62, 75 and 100 milliampères per square centimeter, respectively, at the electrodes. The value of the maximum polarization varies from 2.7 to 2.9 volts from a concentration of 1 per cent. to a concentration of 15 per cent., and is therefore nearly constant. The conductivity shows a very similar behavior, attaining a maximum which appears to become a constant. In the case of platinum, as well as aluminium electrodes, the resistance at high values depends almost exclusively upon the surface of the electrodes. The variations of resistance, therefore, pertain to the surface of the electrodes, and may, therefore, be called resistances of transition. The article will be found abstracted briefly in the Lond. *Elec.*, March 27th.

Electrolytic Dissociation of Platinum by Means of Alternating Currents.—RUER has recently made an investigation of the dissolving of platinum in various electrolytes under the influence of either or both alternating and direct currents. The electrolyte was contained in a U tube, in one arm of which there were two electrodes connected to a source of sinusoidal alternating current. In the other arm there was a third electrode, which was the cathode in a direct-current circuit, one of the two electrodes in the other arm acting as anode in this direct-current circuit. He first experimented with platinum in a sulphuric acid solution, containing two parts of acid to one part of water, and found that, under these conditions, the platinum is not dissolved by the alternating current alone as long as there is no oxidizing agent in the solution. It is dissolved, however, by the combined action of alternating and direct current, as above described. It is dissolved also by the

alternating current alone when an oxidizing agent, like chromic acid, or even oxygen, is present. Most of the other electrolytes which were investigated behaved in the same way as sulphuric acid. But in some electrolytes, like hydrochloric acid, sodium chloride, etc., in which one ion has a tendency to form a complex ion with platinum, alternating current alone dissolves platinum without the presence of oxidizing agents, but in these electrolytes the platinum is also dissolved under certain conditions by direct current alone. He assumes that the attack on the surface by alternating current is due to a formation of a very thin layer of oxide when the platinum is the anode, and to the subsequent reduction to a lower soluble oxide when the platinum is cathode. Passive iron behaves similarly to platinum, and he concludes by analogy that the hypothesis of the passivity of iron is due to a layer of oxide is not impossible. The original is in the *Zeit. f. Elektrochemie,* March 19th.

Dielectric Constants of Liquids.—An account of observations made by TANGL, extending over a wide range of temperature, is given in the *Ann. d. Phys.,* No. 4. As it has been found that the Clausius-Mossoti formula depends upon the temperature, the present author has investigated whether the formula could be used as an index of chemical change, more especially in view of the parallelism between the dielectric constant and the degree of dissociation indicated by Nernst. The results show that Nernst's method is available for temperatures ranging from 20 to 180 degrees in the case of benzol, toluol, xylol, carbon bisulphide and chloroform, and that ether can be followed right up to its critical temperatures (192 degrees). The first-named liquids show a practically linear decrease in the dielectric constant. Ether and chloroform show nearly the same course, but as the former approaches its critical temperature there is a rapid falling off. Ether also shows an anomaly in its dielectric constant at the critical temperature, being still much greater than the square of its refractive index for infinitely long waves. Of the substances enumerated, xylol is the only one which gives a constant value in the formula. In the other substances there is a decrease of from 5 to 17 per cent. between 0 degree and 200 degrees. An abstract may be found in the Lond. *Elec.,* April 3d.

Electric Properties of Gaseous Mixtures.—An experimental investigation of the effect of the electric "effluvium" upon gases has been made by BOUTY, and is briefly referred to in the Lond. *Elec.,* April 3d. The electric discharge, called by him the "effluvium," is incapable of changing the physical or chemical constitution of the gas through which it passes. It does not produce the explosion of an explosive mixture, nor does it produce an appreciable change in the pressure of the gas. He has also investigated the dielectric strength of mixtures of hydrogen with various other gases. At high pressures the critical field is sensibly a linear function of the pressure, independently of the thickness of the gaseous layer, whereas at low pressure the walls exert a complex disturbing action, either on their own account or through a gaseous layer condensed upon them. The author, therefore, confined his experiments to pressures above several millimeters of mercury. In one class of mixtures the critical field is the exact mean of the critical fields of the gases taken separately at the pressure of the mixture. Such mixtures are those of CO and CO_2, or CO and H, which do not act chemically upon each other. It is more remarkable that the same law holds good for a mixture of nitrogen protoxide and hydrogen. Another remarkable case, but in the other sense, is the decided reduction of the critical field in a mixture of hydrogen and carbon dioxide. The original is in the *Comptes. Rendus,* March 16th.

PRIMARY AND SECONDARY BATTERIES.

Measuring the Internal Resistance of a Battery.—In all the ordinary methods of measuring the internal resistance of a battery there is an error, due to the running down of the cell. But this error may, it seems, be reduced to a minimum in the following two methods described by OATES, which require no special apparatus, are easily worked and are accurate within 0.1 per cent. or less. The first method consists in comparing the potential difference between the poles of the given battery on open and on closed circuit by means of a potentiometer, as shown in the adjoining diagram, Fig. 1. The sum of the resistances $r_1 + r_2$ is held constant during the tests, say, at 15,000 ohms; L is a source of current, say, two Leclanche cells; S, a small adjustable resistance; G, a galvanometer; B, the cell to be tested; *r*, a resistance, and *a, b, c* mercury cups for making connections. If the resistance *r* is 5 ohms, then the resistance between A and b is known to be 5 ohms plus a small fraction of an ohm. The test consists of two steps. First, the resistance AD is so adjusted that on joining c to b by a thick copper bond there is no deflection of the galvanometer. Second, *a* is joined to *b*, and immediately afterwards to *c*, the resistance AD being adjusted so that, while AC has the old value, the drop in potential along AD equals that along Aa.

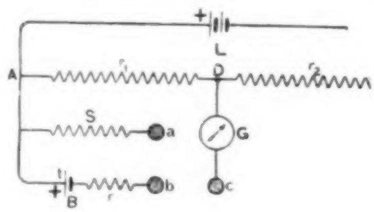


FIG. 1.—MEASURING THE INTERNAL RESISTANCE OF A BATTERY.

Then, if the cell did not run down, there could be no deflection of G. But in practice this is never attainable, and it is necessary to get the smallest possible deflection in the direction in which B alone would deflect G. From the two values of the resistance, AD in both cases, the internal resistance of B can easily be calculated (the final formula is not given in the original). The accuracy of the method depends upon the shortness of the interval between the short-circuiting (connection *ab*) and the connection to the galvanometer (connection *ac*). He adjusts this interval in a very simple manner by making the connections between *a*, *b* and *c* by a piece of thick copper wire, bent into three limbs, one of which fits into each mercury cup a, b, c. The limb fitting into c is cut about ½ cm shorter than the other two; then, on dropping the three arms into the cups, the cell is short-circuited automatically just before it is joined to the galvanometer. Further adjustment is possible by adjusting the level of the mercury in the cups. The

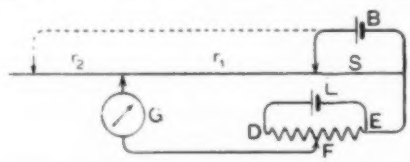


FIG. 2.—MEASURING THE INTERNAL RESISTANCE OF A BATTERY..

second method consists in equating the drop in potential between the terminals of the cell, when short-circuited through a small resistance, to a known fraction of the potential difference between the terminals joined through a large resistance. The simplest form of connections is shown in Fig. 2, in which B is the cell under test, S the small resistance and $S + r_1 + r_2$ the large resistance. These two potential differences are equated by making an auxiliary (third) potential difference on a potentiometer equal to the first p.d., and then making the second p.d. equal to the third, as will be seen from the diagram. Results are given of the test of a small storage battery in series with about 5 ohms. The results of both methods agree with one another, and are certain within 0.1 per cent. Further details are given in the Lond. *Elec.,* April 17th.

Galvanic Cells.—MUGDAM concludes his long article in the *Chem. Zeit.* April 1st and 15th. The galvanic cell, together with a motor, is, theoretically, the most perfect machine for

changing chemical energy into mechanical work, but in practice the case is different. Only those chemical reactions can be utilized in a galvanic cell in which ions take part, and therefore the number of chemical reactions which can be utilized in a cell is limited. In spite of its bad efficiency, the use of the steam engine is the cheapest method in practice. The two disadvantages of galvanic cells are that the available chemical reactions are expensive, and that there are losses in galvanic cells, although they are smaller than in engines. The author briefly discusses the cells used in practice, and makes some remarks on the use of aluminium as electrode. He then discusses carbon cells, and, after some theoretical remarks, mentions that from Nernst's calculations of the free energy corresponding to the process $C + O_2 = CO_2$, the e. m. f. of the ideal carbon cell would be about 1 volt. Experiments made to construct a practical carbon cell are then noticed. They are said to be very insignificant, as in none of the cells devised has it really been proved that the small electric energy given out was indeed due to the oxidation of the carbon. He then refers to some indirect ways of solving the problem, and mentions, for instance, the Daniell cell, in which the zinc sulphate which is formed may be regenerated by means of carbon into zinc and sulphuric acid; and in the same way the copper formed may be changed to copper sulphate by means of this sulphuric acid and air, so that the cell may be used in a cyclic process, in which it gives out energy, while only carbon and oxygen are consumed. But he remarks that this very uneconomical and complicated device can scarcely be considered as "a carbon cell." In summing up, the author states that a cell in which the oxidation of carbon renders work is quite possible, but the technical difficulties are enormous, especially the internal resistance, polarization, self-discharge, impurities, the problem of diaphragms and, above all, the question of the cost of installing and maintaining. This latter point should be carefully taken into consideration.

Storage Batteries.—Among the other articles involving storage batteries are two which give some notes on the recent automobile exhibition in Agricultural Hall, in London, and on the German automobile exhibition in Berlin. Another is by GOETZ, which is a continuation of his serial on the electric lighting of railroad cars. All three articles are in the *Centralblatt f. Accum.*, April 1st and 15th.

GENERAL AND MISCELLANEOUS.

Electric Ore-Finding System.—Until not very many years ago there were many believers in a mysterious rod, termed, we believe, the "divining rod," which had the remarkable property of pointing to places where underground sources of water or springs could be found. A description of something similar, and even more useful, as it shows where valuable ores can be found, is described in the Lond. *Elec.*, April 3d. It was devised by DAFT and WILLIAMS, and was recently exhibited at the Telacve lead mines, in North Wales, England. It differs from the first mentioned in that it points out the location of something more valuable than water, and that it is based on what appear to be rational principles, instead of mysteries, and it is hoped that it may therefore turn out to be more useful. The method requires no expert knowledge to operate it. The transmitting apparatus consists of a large induction coil, the secondary of which is earthed and shunted by a condenser. A secondary battery is used to energize the induction coil, and the potential at the terminals of the secondary winding is about 30,000 to 40,000 volts. Earthing is effected by means of steel spikes, driven about 9 inches into the ground. Both the transmitter and receiver connections are shown in the adjoining diagrams. The principle of the system is expressed in the belief of the inventors that electric impulses or "waves" are radiated by the transmitter in ever-widening circles, and that therefore, under normal conditions, the time of maximum intensity—that is, a line on which they should obtain the loudest effects in a telephone receiver—will be found at right angles to a straight line joining the two transmitter terminals. When the receiver spikes are stuck in the ground in the immediate neighborhood of this line, and the receiver responses are found to be louder than at any other spot on a semi-circle drawn through this point, with its center midway between the two transmitter terminals, then it may be assumed that the conditions are normal, and that no metallic lode exists in the immediate neighborhood. But if the best effects are not heard in the receiver when it is over or near this line of normal maximum intensity, but at a point some distance away, then it may be inferred, according to the inventors, that a metalliferous vein exists within no great distance, because it is assumed that the impulses or waves are diverted from their normal course by a metallic lode. By varying the position of the transmitter spikes, it is possible to throw the line of normal maximum intensity in any desired direction, which may be selected at random or from geological knowledge of the locality. The inventors claim that they have in one instance discovered a new vein of metal in an apparently worked-out mine, and that on recommencing work very successful results were obtained. Editorially, this journal says that it is somewhat difficult to see how the system could be used to determine with any degree of accuracy the depth, nature or quantity of the lode, and therefore to be able to say whether or not it would be worth attempting to recover. But if it will only locate the position of the ore, a great advantage will have been gained. The system is still in its early stage.

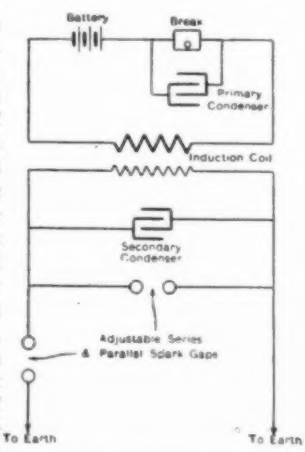


FIG. 1.—TRANSMITTER.

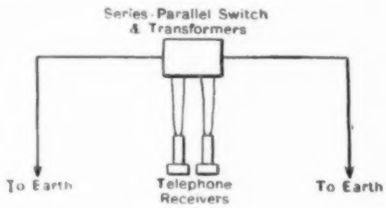


FIG. 2.—RECEIVER.

AMERICAN INSTITUTE OF MINING ENGINEERS.—It has been announced that the meeting for July next in British Columbia, with an excursion to Alaska, has been rendered impracticable by the withdrawal on the part of the Canadian and American railroads of assurances previously given as to cars for the proposed trip. The Pullman Co. had been able to assure the Institute of ample cars for one way, but could not provide the equipment for the return journey. The reason for this step is the unprecedented demand for cars for the regular traffic. Applications and negotiations in every possible quarter have resulted in the conviction that it is impossible to secure even one special train for the journey to British Columbia and back. The abandonment of this trip is doubly regretted, because it is known that in many cases other plans for the summer have been given up for this excursion; and friends of the Institute in British Columbia and Alska had in view elaborate entertainment, and committees have been actively engaged in arranging the details.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By George P. Scholl.

Electric Furnaces and Furnace Products.

Method of Heating Material. E. G. Acheson, Stamford Township, Canada, assignor to the Acheson Co., of Niagara Falls. Patent No. 723,631, March 24, 1903. Application filed September 26, 1902.

This invention relates to a method of conducting operations which are dependent upon definite temperature conditions. The specific instance to which the method is applied is the production of the so-called "white stuff," an amorphous compound, produced in the carborundum furnace at a temperature lower than that necessary for the formation of carborundum. The materials present in a carborundum furnace at the end of the run consist of the carbon core, the body of carborundum, a thin layer of "white stuff" and the undecomposed charge, in the order named, from the center outward. The temperature limits, between which this white stuff is formed, are comparatively narrow, being between 3,500 and 4,000 degrees, and the difference between the temperature required for the production of white stuff and the temperature at which it passes into carborundum does not exceed a few hundred degrees. The white stuff, on analysis, shows the following composition: Carbon, 37 per cent.; silicon, 59.1 per cent., leaving 3.6 per cent. for iron, aluminium, calcium and oxygen in undetermined amounts, the metals having been introduced through impurities contained in the charge. In order to convert the whole charge of a furnace into this white stuff, the furnace has to be so constructed that the temperature to which the charge is subjected does not run up to that temperature at which carborundum is formed, nor

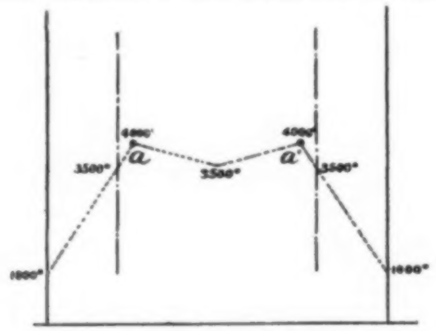


FIG. 1.—DIAGRAM OF DISTRIBUTION OF TEMPERATURE.

fall below that necessary for the production of white stuff. For this purpose Mr. Acheson provides several heat-distributing centers, the regions of maximum heat being so placed in relation to each other that the temperature of the intermediate minimum shall not be less than the inferior limit of the reaction. The sketch, Fig. 1, shows the distribution of temperature when two regions of maximum heat are employed. In a practical furnace, of course, the number of these regions may be indefinitely increased to suit the needs of the operation, the only condition being that they shall be so located that the intermediate minima afford sufficient heat for the accomplishment of the desired reaction. As an instance of application of the method on a practical scale, Mr. Acheson states that he has employed a furnace 48 inches long, 25 inches deep and 25 inches wide, filled with a charge of carbon and sand. Within the charge mixture were embodied four cores of granular carbon, each being 48 inches long and 2½ inches in diameter. This furnace was operated for twelve hours. The voltage throughout was about 80, the current at the moment of starting being 500 ampères, and increasing to 1,500 ampères within a few minutes, where it remained approximately constant to the end of the run. On opening the furnace it was found that the desired product, white stuff, had been formed, and that the reaction had involved all of the material confined within the cores and the material lying outside of the cores for a distance of 3 inches. Mr. Acheson states: "It is not sufficient for the operation of my method that a series of heating conductors be employed, nor does a series of conductors equally spaced and embedded in the charge constitute of itself an apparatus capable of carrying out my method. It is necessary that the resistance conductors or other devices for the application of heat to the mass of material be definitely spaced with relation to each other, at distances largely determined by the heat conductivity of the charge, the duration of the operation and the superior and inferior temperature limits of the operation. Under such conditions only will the temperature variations within the mass of material under treatment fall within the temperature limits of the operation. . . . My invention is not restricted to electric-furnace operations, nor to operations taking place at high temperatures, but is applicable in general to such processes as require for their most efficient conduct definite temperature conditions throughout the mass under treatment."

Electric Furnace. C. S. Bradley, New York, N. Y. Patent No. 723,643, March 24, 1903. Application filed June 19, 1900.

The furnace belongs to the rotary, continuously-working type of furnaces, and is applicable to the reduction or forma-

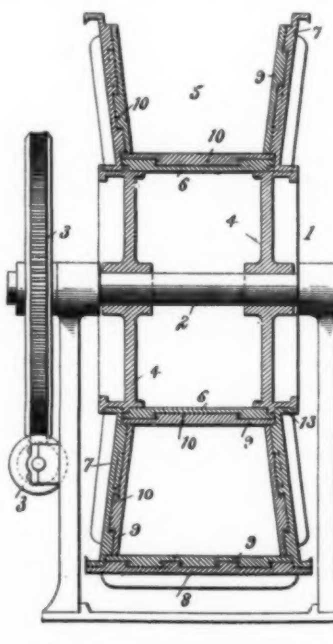


FIG. 2.—BRADLEY ROTARY FURNACE.

tion of refractory materials, but probably, as his former furnace of that type, is intended to be used for the production of calcium carbide. Such furnaces consist of a rotary wheel with a hollow rim, which serves as a receptacle for the charge. Electrodes dip into this rim at one point on its circumference, and there the formation of the product takes place. The product is carried away from the vicinity of the electrodes by the rotation of the wheel. In order to keep the fused material from spilling, plates are then fastened to the outside of the rim, which are removed when the material has sufficiently cooled down so as to make it possible to remove it. Furnaces of this type presented several disadvantages when worked on a

practical scale. When the wheel is made of cast iron, the outer portions of the charge are relied upon to protect the rim; and therefore it is not possible to apply heat enough to have the whole charge enter into reaction, with the result that a considerable portion of the charge is wasted. Still more waste is produced by the necessity of separating the unfused or partially-fused part of the charge from the fused mass after the latter has been taken out of the furnace. In order to overcome these difficulties, the furnace under consideration is constructed in the manner shown in cross section in Fig. 2. The wheel is mounted on a shaft 2, with driving gear 3. The annulus 5 is U-shaped, and is made up of a series of interior plates 6, flange plates 7 and cover plates 8, for the purpose of holding the material, as stated above. In order to make it possible to subject the whole charge to the action of the current, a facing of graphite 9, of suitable thickness, is provided, which is dovetailed into the iron plates. As the lining material is somewhat soft, and might be injured when a charge is being removed, the flange plates are flared outwards, in order to facilitate the removal. It is claimed that the work may be carried on until the fusing has been continued throughout the mass right out to the lining. All the material in the furnace is reduced, no hewing off of material being necessary, and much labor is saved. It is not expressly stated in the specification whether two independent electrodes are to be used, as in the Horry type of furnace; or whether the carbide charge is to constitute one pole and a carbon electrode the other, as in the former Bradley furnace. It is obviously intended to cover the use of the improvement with both types.

Electric Furnace. Robert Winter, Berlin, Germany. Patent No. 724,069, March 31, 1903. Application filed August 7, 1901.

This furnace is intended for dental purposes. The heating plates, containing the electrically-heated wires, often extend in these furnaces over the entire inner side of the furnace. In consequence of the very strong heat to which they are subjected, the plates change their structure and shape, become strongly bent and finally break. As the heating wires are quite immovably imbedded in these plates, the plates, when broken, do not allow them to contract when the furnace cools down, and consequently they break. To avoid this drawback, according to the present invention, the heating walls of the furnace are not constructed in the form of plates, but are built up of a number of single hollow rods containing the wires quite loosely, while they themselves rest freely with their ends in grooves provided in the heating space of the furnace. Between each two of such hollow rods preferably small spaces may be provided, so that the sides of the rods, as well as their front faces, can radiate the heat received from the incandescent wires. The length and thickness of the rods are so determined that they can freely expand in all directions.

Electrical Smelting Apparatus. R. L. Barnhart, Charleroi, Pa. Patent No. 724,778, April 7, 1903. Application filed May 14, 1902.

This is a furnace especially intended, according to the inventor, for the reduction of gold, silver and copper ores. In its construction the well-known principle of compressing the pasty material which is to be treated into rods or bars, and using them in this manner as electrodes, between which an arc is sprung, is made use of. The apparatus consists essentially of two cylindrical drums, situated opposite each other with their small ends. They are provided with a hopper for the feeding in of the pasty material, and a screw rotates in the interior of each drum, forcing the material through a cylindrical head provided with passages, for the purpose of compressing it into the form of rods or bars. A box of firebrick is disposed between the two heads, possessing openings corresponding to those in the heads. Current connections are made to the two heads, and as the rods are forced out into the middle insulating firebrick chamber the arc is struck between them, and they are melted. The matte and slag produced drop through an opening in the bottom of the insulating firebrick box onto a rotating conveyor apron, formed of metallic screening. Spray pipes are arranged between the drums for the purpose of throwing sprays or jets of liquid flux on this screen, whereby, as the inventor says "the screen is kept in a fluxed condition. As the matte and slag fall on the screen, they are acted on by the flux, and the matte adheres to the screen, the slag being scraped off by a scraper. When the screen becomes sufficiently charged with matte, the screen should be taken off the machine and subjected to a refining process, while a new screen should be applied." The cost of the various operations of pulverizing, smelting by the arc., etc., as compared with the present metallurgical operations, does not seem to have troubled the inventor very much. The idea of spraying a "flux," composed of 10 pounds of sal ammoniac, 5 pounds of borax, 2 gallons of saturated solution of zinc chloride, 10 to 15 gallons of water and 1 to 2 pints of glycerine, on a molten material is certainly a novel one, though its efficacy may be doubted.

Ore Separator. H. G. Johnson and M. S. Howard, Waukon, Iowa. Patent No. 724,705, April 7, 1903. Application filed September 5, 1902.

The apparatus described in the specification is not an ore separator at all, but is intended as a contrivance for roasting ores by means of the heat furnished by the electric current. The apparatus is primarily designed for roasting copper ores, in order to change them from the sulphide into the sulphate, which is then treated by any of the ordinary metallurgical processes. It consists of a rotating conical shell, in the center of which there is arranged a tube concentric with the shell. The ore is fed from a hopper into the outer shell, which is provided with longitudinal scraping devices, for the purpose of agitating the ore and distributing it evenly. The ore travels by gravity down towards the larger end of the conical casing, and is there caught in pockets and elevated by the revolution of the casing into a second hopper, which delivers it into the inner tube. This tube is also provided with longitudinal devices for agitating the ore, and a longitudinal, perforated pipe is arranged in its center for the purpose of supplying air to the heated ore. The current travels through the inner tube and passes into the outer shell at the narrow part of the apparatus, and from there back to the dynamo.

APPARATUS AND PROCESSES FOR THE ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Art of Operating Electrolytic Cells. E. A. Le Sueur, Sault Ste. Marie, Canada. Patent No. 723,398, March 24, 1903. Application filed April 24, 1901.

This invention is designed to improve the efficiency of electrolyzers with porous diaphragms, and especially of electrolyzers used to decompose aqueous solutions of the alkali chlorides. The apparatus is a sort of Hargreaves apparatus with an asbestos diaphragm, which separates the anode from the cathode compartment. The cathode of wire netting is fastened to the diaphragm on the side towards the cathode compartment, and is therefore only in contact with the alkali chloride solution by means of the diaphragm. The level of the liquid is higher on the anode side than on the cathode side, with the result "that a tendency is set up to cause flow of the solution from the anode side to the cathode side of the diaphragm, and thereby oppose the tendency, which always exists, for the products of decomposition in solution at the cathode to find their way into the anode compartment, to the serious prejudice of the cell's efficiency." It is stated further: "With a view to further minimizing the objectionable tendency just mentioned, I practice the invention, which is the subject of the present application, by adding water to the liquid contents of the cathode compartment, preferably in a continuous stream, the said water being preferably of a lower temperature than that existing in the anode compartment, and I allow it to displace from the said cathode compartment an equivalent volume of an

alkaline solution. The effect of said addition of water is twofold: It dilutes the alkaline solution in the cathode compartment, and thereby renders less objectionable the results arising from the diffusion of a given volume of said solution into the anode compartment. It also, by reducing the temperature of the cathode compartment, minimizes the diffusive powers of the liquid contents of said compartment, which powers rise with the temperature. I am aware that it has previously been proposed to add hot water or steam to the cathode compartment of cells, but the object aimed at and accomplished is quite different from mine, in that the amount of such addition has only been enough to make up for lack of passage of liquid from the anode compartment in quantity sufficient to dissolve to a strong solution the alkali formed on the cathode." The last paragraph is evidently intended to emphasize the difference between this method of operation and that of Hargreaves.

Electrolytic Cell. Rudolph Johanns, Brooklyn, N. Y. Patent No. 724,580, April 7, 1903. Application filed December 11, 1902.

The apparatus is intended for the electrolytic decomposition of sodium or potassium chloride solutions, and is shown in vertical transverse section in Fig. 3. The cell 1 is made of iron, and is lined with a non-conducting material 2, glass or cement being suitable for this purpose. The anodes 7 are bars of platinum or carbon, and are arranged in a direction at right angles to that of the cathodes. A series of rods 6, preferably of iron, serve as cathodes. Each cathode rod is surmounted and partially inclosed by a hood or inverted channel 8, of glass or cement. These hoods are intended for the purpose of collecting the hydrogen which is generated during electrolysis. The hydrogen is supposed to travel along them through the liquid, and be conducted into chambers which are situated at each end of the channels. The brine is fed from the supply tank 9 through pipes 10 and 11, funnel 13 and pipe 14 into the cell. The chief purpose of the several details of construction is to provide for the conduct of electrolysis with the minimum amount of agitation of the electrolyte. It is difficult to see, however, how this can be realized on a large scale in practice, as anyone who has seen the violent agitation of the electrolyte under the influence of a large current will be slow to believe that the hydrogen can be induced to religiously follow the path laid out for it in the drawing under consideration. Another drawback is the large increase in resistance, due to the covering of the cathodes.

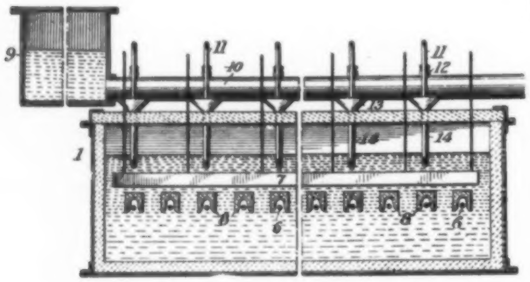


FIG. 3.—APPARATUS FOR ELECTROLYTIC ALKALI PRODUCTS.

Cell for Electrolytic Bleaching Plant. L. E. Lander, Warren, N. H. Patent No. 724,191, March 31, 1903. Application filed September 22, 1902.

This cell comprises a bag-like structure of asbestos or some other similar material which is sufficiently porous to admit of the liquid percolating through, and which is not attacked by the chlorine generated during electrolysis. This bag is supported by a cast-iron framework, with a substantially solid bottom and skeleton sides, constructed in the form of slats. The structure is covered with a cast-iron cover, lined with porcelain enamel. A carbon anode is suspended from the cover, and dips into the asbestos bag. The whole arrangement rests in a cast-iron dish, which serves as cathode, and in which the solution which seeps through the asbestos bag is collected.

Composition of Matter for Electrolytic Decomposition. Edward D. Kendall, New York, N. Y. Patent No. 724,107, March 31, 1903. Application filed September 17, 1902.

The inventor claims to have invented a new composition of matter for the electrolytic deposition of gold. The object of the invention is to obtain a solid composition of matter which, by mere solution in water, furnishes an electrolyte available for the electrolytic deposition of gold by means of an electric current of low electromotive force. He describes his mode of procedure as follows: "I first make gold trichloride in the customary way, by dissolving one part of gold in nitrohydrochloric acid and driving off excess of acid on the water bath. I dissolve this gold salt in a small quantity of water, and then slowly, with constant stirring, add this solution to, preferably, somewhat more than an equivalent quantity of potassium hydroxide—say, two parts, more or less, of potassium hydroxide dissolved in a small quantity of water. Then I add to the liquid and stir into the same a considerable quantity—say, 20 parts—of solid powdered potassium ferrocyanide, finally evaporating the whole to dryness on the water bath with constant stirring. The resulting solid product is my said composition of matter, which, with or without further addition of potassium ferrocyanide, for the purpose of increasing the electric conductivity of any otherwise very dilute solutions of the said composition, and with or without the addition of common salt or any other salt for the same purpose, I generally grind to powder and put into bottles that should be well stoppered. The proportionate quantity of water to be used in forming an electrolyte by solution of my above-described composition of matter, of course, may vary within wide limits."

Cathode. C. J. Henry, Perth Amboy, N. J. Patent No. 724,862, April 7, 1903. Application filed August 6, 1902.

The invention is intended to provide a cathode plate for the deposition of metals of simple construction, allowing the metallic sheet deposited on it to be readily removed, and preventing the deposition of metal on the edge of the plate. This object is attained by a special construction, forming the central portion of the plate upon which the deposit is to be received with a smooth and polished surface. A channel is provided all around this middle portion on both sides of the plate, with perforations at determined intervals. An insulating material, such as putty, is forced into the channel on one side, and, passing through the perforations, will fill up also the channel on the other side. The surface of the putty is then scraped until it is flush with the metallic portion of the plate. After the insulating material has hardened, the area destined to receive the metallic deposit is covered with any of the well-known materials to prevent too close adhesion. After electrolysis a corner of the deposited sheet may be raised, and the sheet stripped off. The insulating material prevents any deposit on the edge of the plate.

Storage Batteries.

Electrode for Storage Batteries. T. A. Edison, Llewellyn Park, N. J. Patent No. 723,449, March 24, 1903. Application filed November 28, 1902.

This specification describes an improvement in electrodes for Mr. Edison's nickel-iron storage cells. Those electrodes are formed of plates with suitable openings, into which are crimped pockets or receptacles, intended to hold the active material. It was found that the active material, when subjected to a charging current, tended to bulge at the center of the pockets, and the plates could, therefore, not be closely placed together, as was desirable. This objection is overcome in the present patent by concaving the pockets by means of dies, so that when any swelling takes place it will not objectionally bulge the pockets. The best results are said to be obtained when two

sets of dies are employed—one for effecting the crimping and concaving of the pockets and one for effecting the corrugating. By transversely corrugating the exposed surfaces of the pockets the strength of the latter is very considerably increased, and thus the use of a lighter sheet metal is permissible. The dies apply pressure to all the pockets of a plate at the same time. Fig. 4 represents a plan view of one of the grids, showing one pocket in position.

Reversible Galvanic Battery. T. A. Edison, Llewellyn Park, N. J. Patent No. 723,450, March 24, 1903. Application filed November 28, 1902.

In the present application Mr. Edison claims mercury, or a combination of mercury and one or more other readily-reducible metals, such as a combination of mercury and copper, as a suitable material for addition to the oxidizable active material of a reversible galvanic battery. He states that mercury, when employed in connection with copper for such addition, preserves the surface of the copper, so that the use of flake graphite can be dispensed with and a better contact be effected between the particles of active material. The cell is also able to sustain a high voltage during the entire period of discharge. The mode of preparation is as follows: To the finely-divided iron, generally in a moist condition, there is added a sufficient quantity of ammoniated copper and of

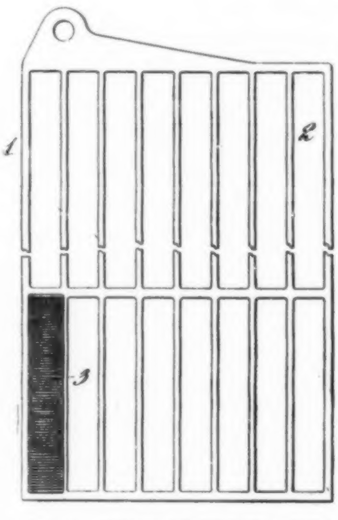


FIG. 4.—EDISON BATTERY ELECTRODE.

precipitated oxide of mercury, in order to obtain as final product a mixture composed of 64 per cent. iron, 30 per cent. of copper and 6 per cent. of mercury. The addition of ammoniated copper and oxide of mercury to the electrolytically-active iron results in the copper and mercury being immediately reduced to the metallic state by the reducing action of the iron, a portion of whose particles become oxidized, while at the same time the particles of metallic copper will be coated with an amalgam of mercury. In the reaction ammonia is liberated as a gas. As a result of this treatment the exterior of each active iron particle will be coated with a porous envelope of amalgamated copper in extremely finely-divided form, mixed with a small proportion of iron oxide. This mixture may be immediately molded into briquettes and used in a battery.

Storage Battery. J. B. Entz, Philadelphia, Pa. Patent No. 723,451, March 24, 1903. Application filed August 28, 1900.

The object of the invention is to provide a storage-battery element, which consists of a plate having a hook-like terminal, that extends opposite the face of the plate and, in conjunction with the wall of the containing jar, serves the double function of a separator and connector.

Armored Element for Electric Batteries. E. A. Sperry, Cleveland, Ohio. Patent No. 723,326, March 24, 1903. Application filed May 25, 1901.

The present invention aims at overcoming the disadvantages arising from the disintegration, abrasion and peeling off of the active material in storage-battery electrodes. The inventor proposes to provide a tough armor of an inert fabric, entirely covering the face of the electrode, preferably in an unbroken web. The fabric is made integral with the electrode by being embedded in the active material. The fabric is preferably made of nitrocellulose or pyroxylin, suitably prepared so as to retain as far as possible the strength of the original fibers. The active material, which is preferably employed in the formation of the armored plate, is a material which at some stage in its operation is plastic or can be made plastic, so that the fabric, when applied by pressure or otherwise, may be thoroughly incorporated with the material. An electrode thus constructed will be found to resist the washing and abrasive action of the constantly-moving electrolyte, and at the same time the armor is so porous that the gases have free passage.

Storage Battery. E. A. Sperry, Cleveland, Ohio. Patent No. 723,327. Application filed August 12, 1901.

This invention relates to the manufacture of hard positive plates for storage batteries, and has for its object to increase the hardness and density of such plates without interfering with the action of the electrolyte on the active material. Finely-divided lead is used as the active material, and a particular menstruum is employed for the purpose of moistening the active material to form the plastic mass, the combination of the menstruum with the metallic lead having the effect of rendering the positive plates denser, and therefore better able to withstand the disintegrating influences to which they are subjected. The menstruum consists of distilled water, to which is added ammonium hydroxide. It is stated that one part of hydroxide to two or three parts of water gives satisfactory results. The dry, powdered substance, which forms the body of the element, and which may by preference be a composition of metallic lead and ammonium sulphate, is thoroughly mixed with the above menstruum, and the plastic mass thus prepared is applied to the grid, which is then dried out under very high pressure.

Storage Battery. E. A. Sperry, Cleveland, Ohio. Patent No. 723,328, March 24, 1903. Application filed August 12, 1901.

The present invention is for the same purpose as the preceding, namely, the hardening of the active material. The menstruum in this case is an alkali metal salt, preferably chemically pure ammonium sulphate, to which is added a catalytic agent, preferably a small quantity of alizarine, about $\frac{8}{100}$ of 1 per cent. The alizarine is said to apparently promote the rapidity of the combination of the ammonium sulphate with the lead in the moistened mixture, after the manner of a catalytic agent.

Connector for Accumulator Plates. G. A. Washburn, Cleveland, Ohio. Patent No. 723,791, March 24, 1903. Application filed, divided, October 6, 1902.

This invention relates to connectors for positive and negative plates in storage batteries. It is claimed: "As a new article of manufacture, a connector, comprising a deep, flat member, disposed longitudinally above the adjacent edges of two adjacent cells, and having downward extensions lying against the walls of the said adjacent cells, said downward extensions being adapted to connect with the plates of said cells."

Method of Producing Storage-Battery Plates. W. Gardiner, Chicago, Ill. Patent No. 724,387, March 31, 1903. Application filed December 13, 1900.

The object of this invention is to hasten the time and cheapen the process necessary to convert metallic lead plates into storage-battery electrodes. The process consists of three steps. The plates are first oxidized in a solution composed of 10 per cent. sulphuric acid, to each gallon of which 5 ounces of

sulphate of aluminium, 5 ounces of nitrate of ammonia and 1 ounce of oxalic acid have been added. A small amount of tartaric acid may also be added. To convert the oxide of lead into spongy lead, the plates are then removed and placed in an electrolyte, consisting of a solution of sulphuric acid, to each gallon of which are added 3 ounces of tartaric acid and 5 ounces of sulphate of magnesia. For the purpose of causing the mass of spongy lead formed by this treatment to adhere more tenaciously to the metal support, the plates are put into a solution of 15 ounces of sulphite of soda and 8 ounces of sulphide of ammonium, dissolved in a gallon of water. The plates should be subjected to the action of the current in this solution for twelve to fifteen hours. The plates should then be removed, washed and finally charged in a sulphuric acid solution having a specific gravity of about 1.2, when they will be ready for commercial service. The third solution may also be composed of water and any soluble sulphur compound having a lower degree of oxidation than sulphuric acid; for example, any of the soluble alkaline sulphides or sulphites, either singly or in combination.

Storage Battery. W. Gardiner, Chicago, Ill., and J. R. McMillan, Menominee, Wis. Patent No. 725,067, April 14, 1903. Application filed January 31, 1902.

This cell consists of tubular electrodes, the positive fitting into the negative, which itself is contained in a cell jar. The negative electrode consists of a perforated shell of chemically-formed sheet lead, fitting about a similarly-perforated shell of hard rubber. The positive electrode of active material is inclosed in a lining of canvas, surrounded by a closely-perforated shell of hard rubber. The upper end of the shell is sealed by wax or a similar material.

Storage Battery. J. M. Allen, St. Louis, Mo. Patent No. 723,804, March 31, 1903. Application filed July 21, 1902.

The essential feature of the invention, according to the inventor, is the construction of the plates, which he has found, from practical experience, will prevent them from buckling. The plates are constructed in the shape of long and narrow rectangular boxes, with thin walls. The positive-pole plates are filled with oxide of lead, and the negative plates with carbonate of lead. And after the plates have been filled and put into the cell, they are submerged in sulphuric acid. The acid enters at the open top of the box-like structures, and is absorbed by the active material. The walls of the battery plates are unperforated.

Process of Making Electric Accumulator Plates. J. J. H. Hunte, Berlin, Germany. Patent No. 724,012, March 31, 1903. Application filed April 15, 1902.

According to this invention, lead plates are subjected to the action of chlorine and oxygen acting in combination, the gases being preferably electrolytically evolved from solutions of certain salts and oxidizing agents, hypochlorites usually being formed at the same time. As an example of a suitable electrolyte may be mentioned a solution of sulphate of soda, in which are dissolved various percentages of chlorides, such as sodium chloride, chlorates, as potassium chlorate and permanganates or sulphate of manganese, which will form a permanganate at the anode. When the above-described action takes place in solutions which show a feeble alkaline reaction, where the plate to be treated forms the anode, the duration of the treatment can be regulated to vary between ten and twelve hours and three to four days, the necessary duration depending upon the concentration, temperature and current density. After this preliminary treatment the plates are removed and connected as cathodes in the same solution. At the end of the second treatment they are found to consist of very porous layers of reduced lead, mixed with some lower oxides of lead, the whole being very firmly attached to the plates and entirely free from chlorides and chlorine. After the second treatment the plates are washed in running water, and connected as anodes in cells containing dilute sulphuric acid.

CURRENT NOTES.

Electrochemical Society.—At the meeting of the Board of Directors of the American Electrochemical Society, held at New York City, on April 16th, the following-named gentlemen were elected members of the Society: H. O. Havemeyer, Jr., New York; Edward Park, Larchmont, N. Y.; Alexander Dick, London, England; F. C. McMillin, Cleveland, Ohio; A. S. Ferry, Lafayette, Ind.; Samuel F. Hall, Niagara Falls, N. Y.; J. E. Mills, Chapel Hill, N. C., and Virgil Coblentz, New York City.

Platinum Robberies.—Messrs. Eimer & Amend, of New York City, send us the following note: "Within the last four months an individual well acquainted with the conditions of chemical laboratories of manufacturing plants, especially iron and steel works, is plundering the chemical laboratories in Virginia, West Virginia, and now Ohio, of their platinum ware. We have had over a dozen such robberies reported within the last four months, and the way the thief goes about it clearly shows that he must have been a former iron chemist, thoroughly acquainted with the conditions of the chemical laboratories in the district mentioned. From what we learn, he is now traveling up the Ohio River, getting into Pennsylvania, and a great service can be done by your valuable medium, if you make these facts known, to put the chemists of iron, cement and steel, etc., works throughout the central United States on their guard against him."

Faraday Society.—The Society of Electrochemists and Metallurgists, which was recently founded in London, as noticed in the March issue of Electrochemical Industry, page 249, has assumed the name "Faraday Society." In our list of members of council the name of Dr. F. M. Perkins was omitted. Dr. Perkins has been appointed treasurer of the Society.

Aluminium Patent Suits.—By a decision of Judge Taft, rendered in 1893, in a suit of the Pittsburg Reduction Co. *vs.* the Cowles Electric Smelting and Aluminum Co., the latter company were enjoined from the manufacture of aluminium. By a recent decision of Judge Wing, this old case has been reopened for the introduction of new testimony and reargument on its merits. The other case between the Cowles Co. and the Pittsburg Reduction Co., wherein the former company is sueing the latter for infringement of the Bradley patent, was argued in New York on April 7th, before Judges Wallace, Cox and La Comb. Messrs E. N. Dickerson and Fred. H. Betts were the attorneys for the Cowles Co.; Messrs. Thomas W. Bakwell, Thomas B. Kerr, George H. Christy and Fred. P. Fish for the Pittsburg Reduction Co.

Erratum.—The authors of the paper on the "Equipment of an Electrometallurgical Laboratory," published in our March issue, on page 241, are R. S. Hutton and J. E. Petavel. By a typographical error the name of the last-named gentleman, who is well known by his investigations in various fields of physics, and especially by his researches on standards of light, had been printed Tetavel, instead of Petavel.

Correspondence.

ELECTRIC FURNACE PROCESSES FOR MAKING IRON AND STEEL.

To the Editor of Electrochemical Industry.

Sir:—In your last issue you have an article by Mr. Louis Simpson on "The Electric Reduction of Iron Ores and the Conversion of Iron into Steel in the Electric Furnace." With the sentiments and generalities therein laid down I am not concerning myself, except wherein he says, "Few of those who have written on this question have published statements that would appeal to the practical manufacturer; that is to say, those who have made it their business to know something about the cost of power production, of electricity and steel making." Further, "One expert condemned employing

hydraulic power wherewith to generate electric power, and claims that electricity can be generated from the combustion of (good) soft coal at a price that will put 'water-power in the shade.' This expert claims that 500 kilowatt hours can be produced by the combustion *under a steam boiler* of 1,000 pounds of soft coal."

He says further "that it is unnecessary to point out that up to date it has been impossible, under ordinary continuous working conditions to produce 500 kilowatt hours by the consumption of 1,000 pounds of any kind or quality of coal, burned under any kind of steam boiler."

These various quotations from the article refer to statements that I have made. I have stated and reiterate that I melt and partially reduce a ton of iron with less than 500 kilowatt hours. I have stated and say now that any good steam-engine builder will gladly take contracts for engines of large unit, guaranteeing to produce a kilowatt hour on 2 pounds of good coal.

In this connection a reference to the April number of *Power*, page 293, recites a test by countrymen of Mr. Simpson's of a small unit (only 300 horse-power), in which the consumption was 15 pounds of steam per kilowatt hour. And it would be a bad boiler or bad coal, or a combination of both, that would not make 15 pounds of steam with 2 pounds of coal.

I have never "condemned the use of hydraulic power." Far from it. But I do condemn hydraulic power *at a price in excess* of what power can be made for by other means. Mr. Simpson also says, "The commercial practicability of the electric process (of iron reduction?) is a question of such complex character that it is difficult for an expert of any one of the several branches of science interested to form a correct judgment upon the question as a whole unless he is posted in all the other branches; and, further, unless he has considerable knowledge of the commercial end of the question. It is not sufficient that this question should be considered by an electrochemist, nor by a hydraulic, civil, mechanical or electrical engineer. It is not sufficient that it should be considered by a metallurgist. It is necessary that the question should be considered by a man of experience in the market for which the steel made by the electric process is intended."

In other words, the man who buys and sells the certain grade of steel is to pass upon the electrochemical, hydraulic, civil, mechanical and electrical problems involved. My own idea of such an individual is that when he is competent to do this he will do something other than "sell steel." He would be hiding his talents too effectually by merely "selling steel."

But is it not to be conceived that, under our American system of specializing, one man may be so wedded to one line of work that he may know the hydraulic, mechanical, electrical, etc., sciences *as applied to his specialty*, so that he may have some right to speak with authority upon any and every question of science and practice as applied to his art?

Marcus Ruthenburg.

Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY ELECTION.

To the Editor of Electrochemical Industry.

Sir:—Now that "the smoke of the battle" has cleared away from the election of the Electrochemical Society, I desire to comment upon the letters concerning it in your issue of March, and espcially upon the views set forth in the letter of the Niagara Falls members.

I voted for Professor Richards as president, and think the time is (as suggested in your March number by Mr. Hering) too early for a change in officers. But it should be understood that every member of the society is eligible for any office in it. It is a reflection of the gravest character on the integrity of a member of the society to assume that he would use his official position in it to advance his business interests at the expense of his fellow-members. Such an idea is fraught with danger, and if the society is to be "rent into factions" the sooner it is dissolved the better. It has no reason for being except to furnish a common meeting ground, free from local jealousies, with absolutely courteous and fair discussion.

The American Institute of Electrical Engineers has had presidents from all of the great electrical industries. I have never heard it suggested that these gentlemen have favored the Westinghouse Co., the General Electric Co. or other interests with which they are affiliated in any official action. Such a suggestion would be resented I am sure, and would make the suggester ridiculous.

Let us have peace. When any gentleman is named for an officer of our Society, let us vote for him or against him on the ground of his personal fitness or want of it, or our personal preferences. But, unless we know the contrary to be a fact, may we not assume that our members are honorable gentlemen? It was wholly unworthy of any members to make a contrary suggestion. No one would for a moment believe it applicable to any one of them.

Yours very truly,

T. J. Johnston.

New York.

[We gladly join Mr. Johnston in the hope that there will be peace. We do not think, however, that in any of the letters published in our March issue the assumption has been expressed that any member of the Society would use his official position in it to advance his business interests at the expense of his fellow-members. A careful perusal of the letters in our March issue will, we think, sustain our view. While we have gladly opened our correspondence columns, without partiality, to all parties concerned, we would not have permitted a personal attack to be made therein. We consider this discussion herewith closed.—Ed.]

THE CASCADE WATER, POWER AND LIGHT CO., CASCADE, B. C., CANADA.

By W. G. McConnon.

The hydroelectric plant of the Cascade Water, Power and Light Co., situated at Cascade, B. C., and owned by the London and British Columbia Goldfields Co., Ltd., has recently been completed, representing an investment, in round numbers, of $500,000. Cascade is a small town on the Kettle River, 12 miles east of the town of Grand Forks, and about 30 miles directly west from Rossland, B. C. Flowing from the west, the Kettle River descends 120 feet in passing through a half mile of narrow, rocky gorge in a series of rapids and falls. For the utilization of this natural power the Cascade Water, Power and Light Co. have built a large dam, waterway, pipe line, power house and transmission line from Cascade to Phœnix, where the largest and most productive copper mines in the "Boundary District" are situated.

The dam, placed just above the entrance to the gorge, is of timber cribwork, with a 40-foot base and 24-foot top. The mid-section is 50 feet high, tapering to 25 feet at the sides, while the total length is 400 feet. This is built on a solid-rock bed, to which the foundation timbers are bolted, and filled with 10,000 cubic yards of rock. This dam raises the water 36 feet above the natural level, giving an effective head at low water of 156 feet. The permanent water level is 10 feet below the top of the dam, being controlled during high water by 12 sluiceways, which can be opened to 12 feet below the natural river level, giving a passway of about 2,000 square feet. These sluices are closed by means of 12 x 12-inch squared timbers in grooves, operated by a traveling winch running on a track over the top of the dam.

From dam to power house the water first passes through a 225-foot open-rock cut, from which it enters a tunnel driven through 410 feet of solid rock, passing under the track of the Canadian Pacific Railway; and then into another open-rock cut 500 feet in length, at the end of which the bulkheads and controlling gates are located. These cuts and tunnel, repre-

senting an excavation of about 35,000 cubic yards of rock, are of dimensions liberal enough to avoid any appreciable loss of head, delivering the water with a head almost equal to that at the dam level.

From the gates the water is conveyed through a wooden pipe, 7 feet in diameter, for about 1,400 feet. This pipe is constructed of Oregon fir tongued and grooved staves, 2¾ x 7 inches, cut in circular segments and machined to the radius of the pipe. The staves are hooped at 12-inch intervals with ¾-inch round steel bands, with cast-iron connecting shoes for clamping. Provisions have been made for the installation of a similar and additional pipe.

From the stave pipe the water is carried through 250 feet of circular steel pipe, 7 feet diameter, resting on concrete piers

FIG. 1.—EXTERIOR OF POWER HOUSE, SHOWING STAND PIPE.

and anchored into solid rock to avoid end thrust. Where this pipe passes alongside of the power house three 4-foot pipes and one 2-foot pipe are taken off below the floor level of the power house to supply three 36-inch turbines for generators and two 12-inch turbines for exciters.

Fig. 1 is a general view of the power house, showing the stand pipe at the junction of the stave and steel pipes. This stand pipe relieves the pipe line from excessive water-ram strains, and incidentally voids any air taken into the pipes.

About 10,000 cubic yards of rock were removed for the site of the power house in a natural bay at the foot of the falls. This building is of substantial fire-proof construction, 150 x 50

FIG. 2.—INTERIOR OF POWER HOUSE, SHOWING GENERATORS.

feet, with stone foundation 22 feet deep on the lower side and brick walls 30 feet above floor level, the height to peak of roof being 45 feet. It has been designed with a view to lengthening it when required.

Fig. 2 shows the interior of the power house and the generating plant. The three generators are standard Westinghouse three-phase, two-bearing, direct-coupled, 2,200-volt, 750 kilowatts at 80 per cent. power factor, or 940 kilowatts at 100 per cent. power factor, 60 cycles per second, 300 revolutions per minute. The two exciters, each capable of exciting all three generators at one time, are 45-kilowatt, 120-volt, shunt-wound dynamos, self-contained, two-bearing type, direct coupled to independent turbines, with 500 revolutions per minute. The turbines are made by the S. Morgan Smith Co., York, Pa., and the governors, the Escher-Wyss make, from Switzerland.

Fig. 3 shows the transformers, nine in all, three in each bank, which are of the standard Westinghouse self-cooling, oil-insulated type, having a capacity of 250 kilowatts at 80 per cent. power factor, or 312½ kilowatts at 100 per cent. power factor, "star" connection, and wound for a ratio of 2,000 to 20,000 volts on both high and low-tension windings, with full-load efficiency of 97.6 per cent. As the taps are brought out near the neutral point, which is grounded, it is impossible to maintain a dangerous voltage in the auxiliary circuit.

The current from the high-tension side of the transformers is carried to a row of high-tension fused circuit breakers, situated alongside of the building, behind the main switchboard. The switches are of the well-known Westinghouse type, placed on independent marble slabs, with marble barriers between. The current leaving these switches enters a high-tension bus, and is carried to the line switches at the rear of the building. These line switches are grouped switches, opening all three wires at the same time. Each switch is furnished with a time-limit tripping device and reversed current-tripping coils, so that overloads can be carried for a period of from one to ten seconds, as the local conditions call for; or either line can be cut out automatically in case of trouble.

The switchboard for the low-pressure side consists of seven

FIG. 3.—INTERIOR OF POWER HOUSE, SHOWING TRANSFORMERS.

panels of blue Vermont marble, one panel for each generator, one for the two exciters and a feeder panel for each group of transformers. The six lightning arresters, located just above the switchboard, in the gable of the roof, are the "low equivalent" style of the Westinghouse Electric and Mfg. Co., giving protection against lightning discharges for transmission at 20,000 volts.

A right of way 132 feet wide is cleared, and transmission lines erected from Cascade, via Grand Forks, to Phœnix, a distance slightly over 21 miles.

The high-tension circuit consists of two separate three-phase transmission lines, each carrying three No. 3. B. & S. copper wires, with room on each line for another circuit. Throughout it is one of the most substantial and best-constructed lines in the Dominion. The poles are heavy cedar, and on tangents are spaced not over 100 feet apart; on curves at less distances, in some cases as low as 50 feet. No angles are turned, but all changes in direction of line made with easy curves. No side or head guys have been used, except at extra heavy spans across rivers, etc.

The work on this line, as well as all construction of the plant, is a decided credit to the company's local engineer, Mr. Wm. Anderson, who has designed and executed the work.

A three-mile feeder is taken off at Grand Forks, 12 miles

from Cascade, to the Granby Smelter of the Granby Mining and Smelting Co., where current is used for driving Westinghouse induction motors of sizes ranging from 3 to 700 horse-power, and of an aggregate capacity of 2,400 horse-power.

The sub-station at Phœnix is located at an altitude of about 3,500 feet above the power house. The building is of brick, with one end left for future extension, and contains the transformers, line switches, fused circuit breakers, switchboards, etc., substantially duplicating those at the power house. For the immediate present this sub-station will be called upon to supply current for two 700 horse-power Westinghouse, type "C," motors for driving two large compressors, a 100 horse-power motor for stone crusher and a 150 horse-power motor for hoist, as well as furnishing the current for lighting the town of Phœnix.

The Cascade Water, Power and Light Co. estimate that they will have a supply at low water for about 6,200 horse-power. This will enable the doubling of the present output. All the plans were made and carried out with the view of extending the plant to its full capacity, and, from present indications, it would seem that the company will have a demand for all the power they can furnish.

EXHIBIT OF ELECTROCHEMICAL APPARATUS.

During the recent convention of the American Electrochemical Society, in New York City, Messrs. Eimer & Amend had arranged a very fine and interesting exhibit of apparatus used for electrochemical work. In the first place, we have to mention an extended exhibit of electric furnaces. Besides those illustrated in our November issue (page 112) and in our April issue (page 297), there were exhibited electric tube furnaces according to Heraeus, with special rheostats for the same; electric melting furnaces according to Borchers, for 100 to 300 ampères at 60 to 70 volts; electric demonstration furnaces according to Moissan, but in an improved form, larger and more accessible than in the old form, for 100 ampères at 50 to 60 volts; electric crucible furnaces according to Howe.

A carbon-determining apparatus, devised by Geo. O. Seward, chemist of the Willson Aluminum Co., was also shown. A detailed description of this very interesting apparatus will be given in our next issue, in which we intend to describe also the chemical apparatus (crucibles, tubes and flasks), blown and drawn, of molten quartz, which are the latest achievement in laboratory utensils.

Among the various other apparatuses exhibited there were polariscopes, various types of pyrometers, laboratory heating appliances, etc. There were also exhibits of electrically-made chemicals, metals and alloys, of Kahlbaum's chemically-pure reagents for quantitative work, etc.

CONVERTING DIRECT CURRENT FROM LIGHTING AND POWER CIRCUITS TO THE LOW VOLTAGE REQUIRED FOR ELECTROLYTIC WORK.

The rapid extension of both experimental and commercial electrochemical work has brought out the need of a motor generator, which, while receiving power from lighting or, comparatively speaking high potential power plants, yet delivers power at the low voltage and high current rate required for such work. It is evident that there is a great field for a reliable, light and inexpensive machine of this kind. Electric light and power for driving machines have been introduced in the past, or are now being introduced in all workshops, and it is quite clear that if electric current is wanted at the same time for electrochemical work it would be preferable to take it from the same mains.

The obstacle has been that for light and power the lowest voltage which has been used was about 100, while for electrolytic work heavy currents at a lower voltage are required. It is well known that while the voltage of alternating current may be easily changed by means of stationary transformers, which require practically no attendance, this is impossible for direct current. It can be proven that to convert direct current from one voltage to another voltage, revolving machinery is absolutely necessary.

The problem in this case was, therefore, the design of a light, inexpensive and absolutely reliable machine, capable of running on any of the ordinary constant potential direct circuits, and delivering current at any voltage from zero up to 5 volts (or more if desired) and of 50, 100, 200 and 500 ampères or higher, depending upon the size of the machine. Such a

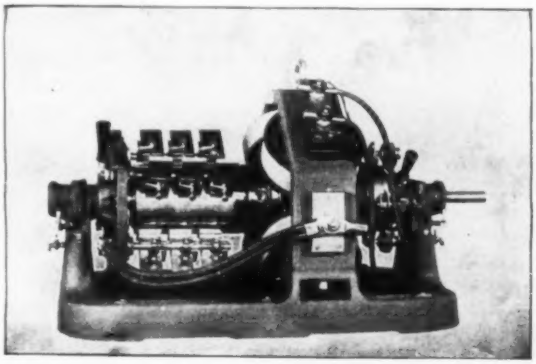


FIG. 1.—2.5 KW MACHINE.

machine furnishes a means of obtaining at any time heavy currents at low voltages, always under perfect control, and so economically that any ordinary lighting plant can furnish the power without difficulty. Such a machine, when used, for instance, in an electroplating establishment, would considerably reduce the cost of operation. At present the current for the electroplating baths is generally taken from a separate

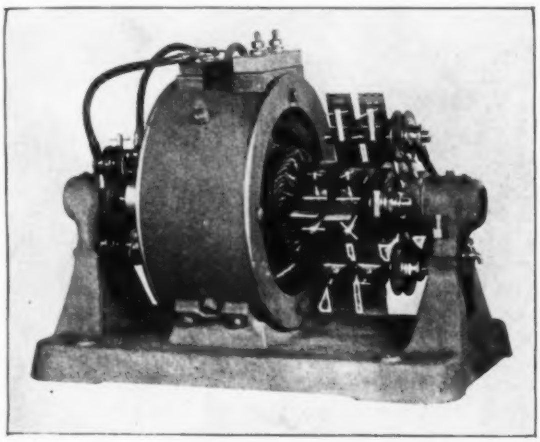


FIG. 2.—1 KW MACHINE.

source of current (a special electroplating dynamo, or batteries, etc.), and not from the electric-light mains. If such a machine as will be described below would be installed, all the electric current could be taken from the lighting circuit. The cost of operation would be reduced, and the whole operation would become simpler and less troublesome. The same remarks hold, of course, good for any electrically-lighted plant in which an electrolytic process is used. In the following we describe a machine, designed and built by the Electro-Dynamic Co., of Philadelphia, for this purpose.

In designing these machines particular attention was given to the demand that they be light in weight, as in many cases the machines are mounted on trucks, thus making them portable. This is easily done, as the machines are small and require no belt connections, and are easily connected to the source of supply by a flexible conductor. The design is such that but

one field and armature core is required—the two windings of the armature, motor and generator—being connected to commutators on opposite end of the armature. Regulation of the output can either be made by a rheostat connected in the motor armature circuit or in the generator circuit. Where the machine delivers heavy currents, it is more convenient to place the regulating rheostat in the motor armature circuit. The accompanying illustrations show two machines of this type. Fig. 1 is a 2.5 kw machine, running at 110, 220 or 500 volts at the motor end and delivering 500 ampères at 5 volts. Fig. 2 is a 1 kw machine, running at 110, 220 or 500 volts at the motor end and delivering 200 ampères at 5 volts. Machines of this type are also made for an output of 100 and of 500 ampères.

The manufacturers, the Electro-Dynamic Co., Philadelphia, Pa., will gladly furnish any information concerning their machines that may be desired.

RESEARCH LABORATORY AT NIAGARA FALLS.

A company have recently been incorporated at Albany, N. Y., under the name of the Niagara Research Laboratories, their object being stated as follows: To maintain a research laboratory for scientific investigation at Niagara Falls; to do analytical and experimental work for the general public; to act as consulting engineers and experts in perfecting and improving existing processes; to rent space, power and the use of the laboratories for physical, chemical and electrochemical investigations; manufacture and sell chemicals and allied products, apparatus and supplies.

The engineers in charge of the laboratory are Messrs. F. M. Becker, L. E. Saunders and R. A. Witherspoon, all well known to the electrochemical fraternity on account of the active part they have taken in the development of processes now in successful operation at Niagara Falls. Among the directors are W. S. Gray and J. G. White, of New York City; W. B. Rankin, of Niagara Falls; N. M. Pierce, Binghamton, N. Y.; W. G. Case, H. J. Pierce, E. B. Stevens and Dr. Elmer Starr, of Buffalo.

Personal.

The numerous friends of Dr. F. Haber in this country will be pleased to hear that, at the request of the German Imperial Commissionary for the St. Louis Exposition in 1904, Dr. Haber has worked out a general plan for the German exhibits of the chemical and apparatus industries. This plan has found the approval of the German Government, as well as of the most prominent representatives of these industries in Germany. It will be remembered that Dr. Haber, who is the professor of electrochemistry at the Institute of Technology at Karlsruge, paid last year an extensive visit to this country.

It is expected that a great number of American scientists and engineers will attend the International Congress for Applied Chemistry in Berlin. Among those who will sail on May 12th are Dr. W. R. Whitney, Schenectady, N. Y., and Mr. Edw. R. Taylor, Penn Yan, N. Y.

Dr. Rudolf Gahl, who was formerly an engineer of the well-known Hagen storage-battery concern, in Germany, has recently accepted a position with the Electric Storage Battery Co., Philadelphia, Pa.

Dr. Th. Zettel, who has been connected with various electrochemical enterprises in Europe, and has translated Moissan's works into German, is visiting this country.

DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

This digest of electrochemical United States patents prior to July, 1902, will be one by classes, setting out for comparison in each class those devices which have the same object, or those methods which seek the same results. In each class the patents will be arranged chronologically. The digest will be complete in the sense of covering every point which is touched upon in the original specification.

690,141. December 31, 1901; Wilhelm Gintl, Aussegg, Austria-Hungary.

Rectangular bells are arranged transversely, in longitudinal series, in an open vat. The bells are of glass or earthenware, surrounded by a sheet-iron casing, serving as cathode. Each bell may have a separate chlorine outlet, or the chlorine may be led from bell to bell, and thence out. A rectangular carbon anode nearly fills each bell, and the brine is introduced above the anode through a horizontal pipe having a series of openings in its upper side. The brine flows down around the sides of the anode or through a series of openings in it, and the caustic solution is continuously drawn off from a point outside the bell. May electrolyze fluorides and carbonites.

690,365. December 31, 1901; Wilhelm Gintl, Aussegg, Austria-Hungary.

The apparatus shown in previous patent.

695,033. March 11, 1902; Edwin D. Chaplin, Winchester, and Henry G. Halloran, Boston, Mass., assignors to Henry Dakin, Boston, Mass.

Separates anode and cathode compartments by a double diaphragm of asbestos cloth, and feeds brine into the intermediate space. Cell consists of a lower circular pan of stoneware and a circular upper portion having an outer depending rim, between which and the pan rim is clamped the diaphragm. An annular partition within and concentric to the outer rim depends from the upper portion, and is secured to the diaphragm by a wooden ring and pins. A single horizontal sheet thus provides a double diaphragm, with space intermediate the electrode compartments. Anodes, an annular series of carbon bars in the outer compartment above the diaphragm. Cathode, a horizontal spiral coil of sheet copper, in the inner compartment, above the diaphragm. A rotatable overflow pipe, with a goose neck at the end, leads from the central cathode compartment, maintaining any desired level.

697,157. April 8, 1902; Frank McDonald, Rumford Falls, Me.

Tank divided transversely by an anode compartment, consisting of parallel, vertical, perforated iron plates, lined with layers of asbestos cloth and paper, which serve as diaphragms. Top of anode compartment closed by a flanged cover of glass, through which extend a plurality of anodes. Each anode consists of a bunch of platinum-foil ribbons, sealed into the lower end of a glass tube, with mercury contact and current wire. Brine is supplied to the anode compartment by a float-feed device. Caustic is delivered from the cathode compartments by rotatable overflow pipes leading from the bottom.

703,289. June 24, 1902; Hugh Kelsea Moore, Lynn, Mass., assignor to Moore Electrolytic Co., Portland, Me., and Boston, Mass., a corporation of Maine.

Cell consists of a vertical, rectangular, open frame of slate, the sides of which are closed by diaphragms of asbestos paper, clamped in place by cathodes, each consisting of a layer of wire cloth and a perforated iron plate. Anode, a series of vertical carbon plates, the lower ends of which rest in a groove in the bottom of the frame. Brine is continuously supplied by an adjustable float-feed device, and percolates through the diaphragms, and the sodium deposited on the cathodes is oxidized and washed down by the excess solution into a shallow pan, which receives the lower end of the cell. Each cathode is inclosed by a casing, which depends into the caustic solution collected in the pan and excludes air, thereby preventing oxidation of the cathode, evaporation of the liquid contained in the cathode, deposition of magnesium or calcium and carbonating of the caustic. The accumulating hydrogen forces its way out through the caustic in the pan. The sides of the cell converge toward the bottom, thereby progressively decreasing the resistance of the electrolyte from the top to the bottom of the cell to compensate for the increased flow toward the bottom, due to the pressure of the column.

The part of the digest of United States patents relating to alkalies and chlorine is herewith concluded.